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MEMOIR OF DR. THOMAS P. JONES.

BY FRANCIS FOWLER.

[Dr. JONES was so closely identified with the origin and early history of the JOURNAL, that the Committee on Publication feels that no further explanation than this statement will be needed in presenting in its pages the excellent memoir prepared for the United States Patent Office by Prof. Fowler. The Committee feels that in making this publication, it is doing only tardy and incomplete justice to the memory of one, to whom the JOURNAL is indebted more than to any other, for the zeal and rare ability with which, as editor, he directed the JOURNAL during the first twenty-two years of its existence. The fact that his colleagues elected him editor for life is the best evidence of the value which they placed upon his services.

The Committee has been able, also, to supplement Prof. Fowler's sketch, with an excellent likeness of the subject of this memoir.—*The Committee on Publications.*]

Dr. THOMAS P. JONES was born in Herefordshire County, England, in the year 1774, and, soon after coming to this country, settled in Newborn, N. C.

In December, 1825, he was appointed Professor of Mechanics and Natural Philosophy in the FRANKLIN INSTITUTE of Philadelphia, which was organized in February, 1824, and he entered upon his duties January 4, 1826. At the same time he was placed in charge of the FRANKLIN JOURNAL as its first editor, the first number having been issued early in that year.

At the annual meeting of the INSTITUTE, January 19, 1826, it was "*Resolved*, That the members view with pleasure the prospect of the FRANKLIN JOURNAL being issued by so able an editor as the Professor of Mechanics in the INSTITUTE, and we recommend it to the support of their fellow-citizens."

In the same report it was stated that "Dr. JONES had consented to undertake the publication of the JOURNAL on his own account, with the assistance of the members and under the patronage of the INSTITUTE."

The address of the editor in taking charge of the JOURNAL is an excellent paper, from which the following extract is taken: "Gentlemen who furnish communications for the FRANKLIN JOURNAL are requested to keep in view that its main object is to diffuse information among artisans and manufacturers; and that it is therefore necessary to write in a style as familiar, and as little technical, as the nature of the subject will admit.

"He earnestly solicits the aid of intelligent mechanics and manufacturers, and assures them that although they may not always be as ready with the pen as with the implements of their respective trades their offerings will be acceptable, and that the labor of revision, when requisite, will be chêerfully performed.

"The age of secrets in arts and trades has nearly passed away. In these pursuits, as well as in that of commerce, liberal views are generally entertained, and a free and open intercourse is acknowledged to be the best policy. The JOURNAL will be a ready vehicle for inquiries and replies upon all subjects within its purview, and will enable the artisan and others to obtain information which might otherwise be sought in vain."

In addition to his other duties, Dr. JONES for several years acted as Recording Secretary of the INSTITUTE and Curator of its Collections.

The original Act establishing the Patent Office was passed in April, 1790, its object as therein stated being "to promote the progress of the useful arts."

The first Superintendent was Dr. William Thornton, a personal friend of Washington, and one of the three Commissioners appointed, in 1794, to lay out the Federal Capital. To the position of Superintendent of the Patent Office, Thornton was appointed in 1802, and held it until his decease, March 28, 1828.

Dr. JONES was appointed his successor April 12, 1828, and he at once removed to Washington. In the preface to Volume 5 of the FRANKLIN JOURNAL, Dr. JONES thus refers to the change:

"It has already become known to the patrons of the JOURNAL that the direction of the National Patent Office has been committed to the editor.

"His induction into this station has been such as to afford him unalloyed pleasure, as his appointment has been made without the slightest reference to political considerations.

"Whilst the station will enlarge the sphere of his usefulness by putting into frequent requisition that information upon the practical application of mechanical and chemical science which it has been the labor of his life to obtain, it will also enable him, through the medium of the JOURNAL, to lay open those stores of the genius and skill of our countrymen, which, although existing in the Patent Office, have hitherto been but partially known."

At the meeting of the INSTITUTE held the same month, April, 1828, the managers express their appreciation of Dr. JONES' services "in a resolution to appoint him editor of the JOURNAL during his life," and in the following annual report is found this record: "The abilities of the gentleman who edits the JOURNAL are known to you all, and we regret that the INSTITUTE has been deprived of his services as the Professor of Mechanics, so well known and respected by all for his urbanity and gentlemanly deportment, whose zeal for the cause of mechanics was only surpassed by his knowledge, from which the INSTITUTE draws so abundantly. The editor's office and station give him an opportunity of noticing all patents as they are issued, and this is done without filling the work with useless and technical verbiage, but by an abstract of the specification, accompanied by the editor's remarks, supplied from a fund of information rarely surpassed."

In the annual report of 1830, this important feature of the JOURNAL is referred to as follows:

"The interest taken in the JOURNAL has been greatly increased by the analysis of patents, which has occupied a large portion during the past year. To those whose attention is called to the construction of new machinery, the knowledge of what has been done by others is of incalculable value, and a work giving a description of all new inventions must be most acceptable."

At this time the personnel of the Patent Office consisted of—

Dr. Thomas P. Jones, Superintendent, salary, $1,500.
William Elliott, Clerk, salary, $1,000.
Alex. McIntire, Clerk, salary, $800.
R. W. Fenwick, Messenger, salary, $400.

Dr. JONES received the appointment of Superintendent of the Patent Office under Henry Clay, Secretary of State, the Patent Office being at that time a Bureau of the State Department, but among the changes made in the first year of Jackson's administration, 1829, was his transfer to the Bureau of Archives, Laws and Commissions in the same department.

This position Dr. JONES held until soon after the organization of the Patent Office, under the Act of July 4, 1836. Hon. H. L. Ellsworth was made Commissioner, on that date, at a salary of $3,000, and Charles M. Keller and Dr. JONES were appointed Examiners, January 4, 1837, at a salary of $1,500 each.

At this time, Dr. JONES was about sixty-four years of age and he remained in the Patent Office only two years longer, resigning his position on the 22d of December, 1838. He continued to reside in Washington during the remainder of his life and devoted himself with unabated zeal to his duties as editor of the JOURNAL. In the annual report of the INSTITUTE frequent references are made to his services, especially in enlarging that part of the JOURNAL devoted to the record of American and foreign patents, to most of which were appended "remarks," showing the remarkable extent, versatility and thoroughness of his knowledge and experience, as well as the unremitted labor and research which the duties involved.

These "remarks," modestly so-called, often embodied scientific matter and treatment of the highest order, as well as criticisms, suggestions and information of great value to inventors and all interested in the practical development of the arts. A collection of these "remarks" would form by themselves a most interesting volume.

It may be truly said that Dr. JONES was at home in almost every branch of mechanics, natural philosophy, chemistry and physics, and was also familiar to a remarkable degree with all the leading practical arts.

The versatility of his talent and acquirements is seen in every issue of the FRANKLIN JOURNAL. For example, in one volume is found an elaborate article on the "Effects of Trades on Health and Morals;" another, on the "Acts of Congress Relating to Patents;" a discussion of court decisions; notices of scientific works; besides detailed descriptions and analyses of *hundreds* of machines patented at home and abroad, from a rotary engine, a machine for sawing marble, a house-heating apparatus, to an automatic chess player.

Also, in the earliest numbers of the JOURNAL are seen the fruits of his extensive acquaintance with the scientific authorities and publications of England and the Continent, including even those of Italy, from which he selected articles and information, which aided so essentially in giving the FRANKLIN JOURNAL the first place among the scientific publications of the country at that time.

Prof. A. D. Bache, of the University of Pennsylvania, in his address before the INSTITUTE, in 1842, sets forth the great value imparted to the JOURNAL by "the copious extracts from foreign journals conveying the improvements of Europe to our own mechanics, a feature commenced and conducted by Dr. JONES."

As showing the interest Dr. JONES took in the improvement of the working classes, the following incident appears in the minutes of a meeting of the Board:

"Application has been made by the Philadelphia Sunday-school Union for the use of the Institute Hall on the Sabbath Day, for the moral and religious instruction of apprentices; and, as this object is in unison with those of the INSTITUTE, it has been determined to let it for that purpose."

When no longer connected with the Patent Office, his interest in the progress and in the development of inventive talent in this country, as well as in the general improvement of the artisan classes continued to the last years of his life.

As editor, he was always ready to recognize and warmly encourage genuine invention; but he was equally watchful and uncompromising in showing the defects he believed to exist in any patented invention, especially in those cases in which the invention embodied no possible advantage or gain to the public, and was, therefore, worse than useless, as the official stamp of patentability might be used to impose on the credulity and ignorance of many.

In the early numbers of the JOURNAL, he published a few articles, entitled "Modern Antiques," the purpose of which, as he says, "is to show the disposition of our remote ancestors to deprive us of the honor of being the true and origi-

nal inventors, and who peep from their graves to dispute the rights of those who have issued to the world their new-born projects."

Dr. JONES died in Washington, March 11, 1848, and was buried in the Congressional Cemetery. He had two daughters, one of whom married Mr. Alger, of Boston.

The FRANKLIN INSTITUTE, in connection with the formal announcement of his death, passed the following resolutions:

"*Resolved*, That the members of the FRANKLIN INSTITUTE have heard with the most profound sorrow that Dr. THOMAS P. JONES, one of the earliest of their associates, departed this life on the 11th day of March last, after a long career of usefulness in the walks of mechanical science.

"*Resolved*, That the services of Dr. JONES as the founder and able editor of the JOURNAL OF THE INSTITUTE, from the time the publication of it was commenced until his death, and also for several years as the Professor of Natural Philosophy and Mechanics in the Institution, will ever be gratefully remembered by all who have participated in the labors and advantages of our Society.

"*Resolved*, That we sincerely condole with the family of Dr. JONES in their recent and irreparable bereavement, and that a copy of these resolutions be transmitted to them by the Corresponding Secretary."

[Entered according to Act of Congress in the year 1890, by Thos. Pray, Jr., in the Office of the Librarian of Congress, Washington, D. C.]

WHAT DOES A STEAM HORSE-POWER COST?

BY THOS. PRAY, JR., M.E., C.E., Boston.

[*A Lecture delivered before the* FRANKLIN INSTITUTE, *December 20, 1889.*]

[*Concluded from vol. cxxix, page 489.*]

WHAT DOES A STEAM HORSE-POWER COST?—NO. 2.

Joule's equivalent = 772· units of work, or heat required to raise one pound of water 1° F., or one pound one foot high.

Unit of evaporation equals 966·1 British thermal units.

$\frac{33{,}000 \text{ pounds}}{772 \text{ Joule's}} = 42{\cdot}746$ of heat units to make one horse-power one minute, and $42{\cdot}746 \times 60 = 2565{\cdot}76$ heat units per hour for one horse-power required.

Then $\frac{2565{\cdot}76}{966{\cdot}1} = 2{\cdot}6558$ pounds of water required, if *no loss*, to make one horse-power per hour.

Good anthracite coal has 14,500 heat units per pound, then $\frac{14{,}500 \text{ heat units}}{966{\cdot}1 \text{ heat units}} = 15{\cdot}082$ pounds of water should be evaporated with one pound of coal, if no loss.

Then $\frac{2{\cdot}6558}{15{\cdot}083} = {\cdot}018148$ pounds coal per horse-power per hour, if no loss, or 5·510 horse-powers one hour with one pound of coal.

Boilers do evaporate ten and one-half to twelve pounds water, with one pound of coal, in regular commercial duty and in 5,000 horse-power plants.

In Table No. 2, we have the heat units and the basis of all computations into which "heat units" enter, and the study of this branch of the question may be considered one of the most bewitching of all, and one that is so little under-

stood. Heat, heat units, sensible heat, latent heat, specific heat, all enter into coal, water, steam and all substances known to man. Heat from the combustion of coal, acting through the boiler shell upon water, causes its conversion into steam, and then the steam in turn acts on a moving medium and overcomes resistance or "*does work*" and is gradually returned to its original water with a higher or lower efficiency in conversion of heat into work. The slide (No. 2) shows the possibilities of heat, or what we could do, if only we were not subject to natural laws. Mr. Joule determined, over forty years ago, that 772 units of work were required to raise a pound of water 1° F., and the same number exactly equals raising one pound one foot high.

The unit of evaporation equals 966·1 British thermal units, required to turn one pound of water into steam at atmospheric pressure. As we wish to know what a horse-power should and does cost, we can begin by ascertaining what the possibilities are. We know that 33,000 units of work constitute a horse-power, and that it requires one Joule to develop a unit of work, then 33,000 ÷ 772 = 42·746, the number of heat units to make a horse-power one minute, and 42·746 heat units × by 60 minutes, give us the number of heat units necessary for a horse-power one hour, or 2565·76, and as we must use water from which to make steam, and we know that it requires 966·1 thermal units to make a pound of water into steam, by dividing 2565·76 by 966·1, we can tell how many pounds of water are required to make a horse-power, if only no loss occur = 2·6558, a quantity very much smaller than we meet with in practice.

We know also that good coal has about 14,500 heat units in a pound, and 14,500 ÷ 966·1 = 15·082 pounds of water should be evaporated with one pound of coal, if no loss, and 2·6558 ÷ 15·083 = ·018148 pounds of coal per horse-power per hour, if no loss, or 5·510 horse-power per pound of coal per hour.

We must now seek the cause for this very wide discrepancy between possible and actual results, for there are more engines that require five pounds of coal per horse-power per

hour, than yield five horse-powers for one pound of coal per hour. We also know that many boilers are running in every-day work that give an evaporation of eight to ten and one-half and even twelve pounds of water with one pound of coal, and this shows only a part of the loss, and we must seek the remainder of "not accounted for" in our next.

WHAT DOES A STEAM HORSE-POWER COST?—NO. 3.

Application of Carnot's Law.

$$\text{Efficiency, } = \frac{\text{Range of temp. above absolute zero.}}{\text{higher limit of absolute temp.}}$$

Initial pressure = 125 lbs. Term. pressure = 10 lbs.
Initial temp. = 361° F. Term. temp. =267° F.

then

$$\frac{361 + 461{\cdot}2 - 267 + 461{\cdot}2}{361{\cdot} + 461{\cdot}2} = \frac{94^\circ}{822{\cdot}2^\circ} = 11{\cdot}432 \text{ p. c. efficiency}$$

Another case:

Initial pressure = 80 lbs. Term. pressure = 54 lbs.
Initial temp. = 334° F. Term. temp. = 314° F.

then

$$\frac{334 + 461{\cdot}2 - 314 + 461{\cdot}2}{334{\cdot} + 461{\cdot}2} = \frac{20{\cdot}}{795{\cdot}2} = 02{\cdot}515 \text{ per cent. efficiency,}$$

or one engine does nearly five time as efficient work in heat units as the other.

Losses.

Imperfect combustion.
Convection of heat to the water.
Leakages of joints, valves, etc.
External condensation.
Frictional condensation in pipes and ports.
Small steam room of boiler.
Excessive clearance in cylinder and ports.
Surface condensation of piston and cylinder walls.
Loss by exhaust into open air or condenser.

We see here Carnot's law, previously referred to, in which the higher minus the lower absolute temperature ÷ by the higher limit of absolute temperature gives us the efficiency in the engine as a heat machine or converter of heat into work. Two instances are given, the one with initial pressure of 125 pounds, terminal of ten pounds, showing a range of 94° F. only, as giving 11·432 per cent. of efficiency, in contrast with which is given an example of a throttling engine with an initial of eighty pounds and terminal of fifty-four pounds, or a range of only 20° F. and an efficiency of only 2·5 per cent., showing one engine as a converter of heat into power with nearly five times the efficiency of the other—in a condensing and non-condensing engine doing the same work, with same boiler and same steam pressure, in one case 156° is the range—the other 82·5°, or almost double the efficiency—while in the condensing engine less steam in volume would be used to effect the overcoming of the same resistance, a fact steam-users frequently fail entirely to comprehend; and in all comparisons, *absolute* pressures and temperatures must be used—not *relative* or *apparent*. And another fact frequently lost sight of is that the ratio of gain *in cost* is greater as higher initial pressures are used up to about 120 pounds; and a noteworthy fact is that Mr. Corliss, for some years prior to his death, used 125 pounds gauge pressure or 140—absolute as the point of best results—where lubrication could be steadily maintained, at minimum cost. The advantages of expansion in his simple compound, like the Pawtucket and Providence pumping engines, with not the most efficient boiler, cause them to show a horse-power with 13·7 pounds of water per hour, an amount seldom approached by even the most recent triple expansion compounds—stationary or marine—and his engines are not up to 300 I.H.P., as compared with 1,000 to 5,000 I.H.P., of the modern types referred to, in which cases, all of most modern appliances for making steam have been fully adopted.

LOSSES.

The items in No. 3 would require an evening to discuss in any way worthy their importance. Rankine has treated

of each in his *Steam Engine* so fully that it is better to refer you who desire to understand the subject, direct to the best authority extant. The form and adaptation of boilers are a study, and the results vary in almost all particulars, when conditions are regarded. ·6 is low and ·75 high accomplished results in every-day practice at the boiler. Leakage and condensation reduce this as more or less care is exercised over pipes and passages. External condensation, caused by lack of covering of pipes, etc., is a material factor of loss. Internal condensation by small pipes, obstacles, as valves, elbows, short turns and various obstructions, frequently cause a loss of twenty-five per cent. in economy and make a large amount of water present.

Small steam-room means water in the steam, and the clearance of engines in cylinder and ports becomes frequently as high as sixteen to eighteen per cent. by the use of single valves and various other ancient adaptations of a so-called economical order. Cylinder condensation causes large losses in heat, running up to thirty or forty per cent. of the realized initial temperature and pressure, while other matters of more or less import enter in and call for necessary factors for comparison.

WHAT DOES A STEAM HORSE-POWER COST?—NO. 4.

Necessary Factors for Comparison.

Coal per one I.H.P. per hour.
Cost of coal per ton.
Pounds of water per one I.H.P. actual.
Evaporation per pound of coal.
Initial steam-pressure, absolute.
Terminal steam-pressure, absolute.
I.H.P.
Calorimetric conditions at engine, and boiler.

Conclusions Necessary.

Cost of one I.H.P. one hour for coal, in mills.
Cost of one I.H.P. twenty-four hours for coal, in cents.
Cost of total load per hour for coal.
Pounds of coal per hour and twenty-four hours, in cents.

Pounds of water per hour and twenty-four hours.

All the above give the only correct comparisons between one and another steam plant as to dollars and cents.

Pounds of coal, without cost of coal per ton, means nothing so far as the cost of a horse-power per hour, day or year goes, and the relative cost of a horse-power in dollars and cents in different localities amounts to nothing beyond an assertion, unless we know the actual number of pounds of water evaporated by a pound of coal, and then we must know for comparison or for fact the amount of water carried over in the steam, for the boiler gets credit for an evaporation that is entirely fictitious, in case a large amount of water is present in the steam, and this is so frequent that no result is worth the time spent that does not embrace all the factors in the first part of No. 4. The calorimeter is at once the most reliable and unreliable factor in the whole, and the so-called "modifications," "improved" and variously-termed traps, called calorimeters, are only to mislead those who suppose a good wooden barrel and scale of no use. The facts are simply expressed, the old-fashioned barrel is as honest and reliable as any, if honestly used, and in a great degree more reliable than any of the "improved" traps so much paraded. Where small quantities are used a small error is a too large factor of percentage, in my own practice 300 or 350 pounds of water are used, to which exactly thirty or thirty-five pounds are added. This makes quick work and does not need any calculus or long formulæ to get results.

Conclusions necessary call for a moment's explanation. Any result for an hour is of no value. Conditions of the atmosphere make a great difference in evaporation, and the amount of moisture in the air is an element of more importance than usually given. Coal burned in ten hours has no place in my results, but the full coal for a week, is taken including "boilers over Sunday" for fire (as is required by the factory mutual mill insurance companies), and all the coal used, in this way all the facts come out.

Some "evaporative" tests of an hour or two on a 500 horse-power engine may be interesting or amusing, but they

cannot be reliable, if we wish to compare the cost of a horse-power for a week or year.

WHAT DOES A STEAM HORSE-POWER COST?—NO. 5.

Coal per I.H.P. per hour, pounds,	2·28	6·05
Cost of coal per ton,	$2.90	$2.25
Pounds of water per I.H.P. actual,	16·84	47·99
Evaporation per pound of coal,	10·31	7·92
Initial steam pressure, absolute,	83·6	94·6
Terminal pressure, absolute,	8·71	17·2
I.H.P.,	151	159
Cost of one I.H.P. one hour (coal), mills,	2·59	6·077
Cost of one I.H.P. twenty-four hours (coal), cents,	6·216	14·58+
Cost per hour (coal), total load (third line above), cents,	39·+	96·62
Pounds of coal per hour for load,	344	961·95
Pounds of coal per twenty-four hours per H.P.	54·72	145·20
Pounds of water per twenty-four hours for one horse-power,	404·16	1,151·76
Water in steam by calorimeter at boiler per cent.,	2·16	2·26
Water in steam by calorimeter at engine,	3·04	21·16
Comparative cost of 1 H.P. same time,	$1.00	$2·4775
Actual cost of 1 H.P. one year, 308 days, ten hours,	$7.98	$18.72

In this, we have a Corliss condensing engine and an ancient throttling slide-valve, under free exhaust, one factor, about the same horse-power. In studying the columns of comparative cost, item by item, some interesting facts appear: Coal per I.H.P., and cost per ton, water used per horse-power per hour, all show a change, in which some items are best one way or the other. The cost of horse-power per year of 308 days, ten hours each, would make a difference of $1,074 only in each 100 horse-power plan, working on the conditions of the right-hand columns over one under the conditions of the left-hand column, the engine of smaller horse-power paying sixty-five cents per ton more for coal, and using steam of lower initial pressure, but showing better evaporative power and better calorimetric results.

The engine of left-hand column was put up under my direction in 1883. The other one is in Pennsylvania.

WHAT DOES A STEAM POWER COST?—NO. 6.

Coal in pounds per hour, per horse-power, . . .	1·57	7·7027
Cost of coal per ton, ...	$4.35	$2.25
Cost of coal per horse-power per hour, in mills, .	3·4	8·1174
Actual water consumption per horse-power per hour in pounds, ...	13·71	59·618
Pounds of water evaporated per pound of coal, .	10·34	7·92
Steam pressure per gauge, ...	130·	80·
Steam pressure, absolute, ...	144·696	94·696
Terminal pressure, absolute, ...	5·619	70
Initial pressure, absolute, ...	146·341	82
I.H.P., ...	138·056	249
Cost of one I.H.P. for twenty-four hours, in cents,	8·166	19·48
" " " for 308 days of ten hours each,	$10.48	$24.98
Coal per I.H.P. for twenty-four hours, in pounds,	37·68	184·86
Water " " " " " "	329·004	1430 83
Water in steam per calorimeter, at engine, per cent.	2·31	21·14
" " " " boiler, "	1·74	1·87
Duty for twelve months from Log for 100 pounds coal, ...	113,439,331	19,068,000
Comparative duty, ...	5·949	1

Table No. 6, left-hand column, is from the Pawtucket Pumping Engine in 1879, and I am told that Prof. Denton, of Stevens Institute, repeated the test in 1889, with results of nearly the same amount of water per horse-power per hour. The column at the right hand is a pumping engine in Pennsylvania, new in 1887 or 1888. Notice there is a difference of $2.10 in the cost of coal per ton; one engine has over 100 horse-power more than the other; great difference in terminal pressure, as well as initial; one engine using 13·7, the other 59·6 pounds of water per I.H.P., the amount of coal per I.H.P. being 4·9 times as much in one case as in the other; the boilers varying very *slightly* in the amount of water present in the steam at the boiler, very *largely* in that at the engine. Yet in total result the Corliss engine horse-power costs only $10.48 for 3,080 hours, the other engine $24.98.

There can be no better example of Carnot's law of efficiency than in these two engines, and if the Corliss engine had coal at $2.25 its horse-power would be diminished inside of $6 for 3,080 hours, or one-fourth the other pumping machine; and if we consider the ratio of work done by 100

pounds of coal in proportion, the ratio of actual cost between the two engines becomes an enormous one. The duty shown on the screen is not the one at first said to have been made, and which Mr. Corliss denounced as "humbug." The "experts" built a fire, then counted the coal used, and when finished left water, etc., "as at commencement," and pronounced the duty as "133 millions 1 foot high, with 100 pounds coal." Mr. Corliss called it "a humbug," and insisted on a "common-sense" test under the conditions of every-day life. The duty shown on the screen is from the engineer's log-book. A laughable incident in connection with "the reason why Corliss attained such a duty" is worth mention here. The "why" was that "some place about the boiler was filled with coke which, when ignited, became incandescent and so remained for a long time, thus giving out heat for days." The fact is and has been that the engine *was* and, for aught I know, *is* run by Corliss upright boilers; and if any man can stow coke, except in the fire-space, it will be a good plan to know where it can be done.

WHAT DOES A STEAM HORSE-POWER COST?—NO. 7.

Using Back Pressure for Heating.

Cost of coal per ton,	$4.60	$2.20
Coal per I. H. P. per hour, pounds,	2·54	9·65 +
Pounds of water per I. H. P., actual,	26·28	72·
Evaporation of water per pound of coal,	10·84	7·46
Initial steam pressure,	104·6	94·6
Terminal pressure,	24·6	57·6
Total I. H. P.,	542·	346·
Cost of one I. H. P. one hour for coal, mills,	5·2161	9·5638
" " " 24 hours for coal, cents,	12·518	22·95
Cost of coal for the whole load of engine one hour, cents,	282·71	330·91
Pounds of coal per I. H. P. for 24 hours,	60·96	231·6
Pounds of water per I. H. P. for 24 hours,	630·72	1728·
Water in steam by calorimeter at boiler, per cent.,	2·36	1·94
Water in steam by calorimeter at engine, per cent.,	4·16	14·27
Water in back pressure steam by calorimeter, per cent.,	16·4	36·38
Percentage of total power in back pressure,	20·	40·

Cost of 1 horse-power 308 days of 24 hours each, ...	$38.55	$70.69
Cost of 1 horse-power 308 days of 10 hours each, ...	16.48	29.45

The use of back pressures for heating is various as to appliances and purposes—an instance is shown between a Pennsylvania concern, with coal at $2.20 per ton, and a New England (mixed power) cotton mill using coal at $4.60 per ton, and nearly 100 miles railroad haul from water, the coal in left column costs over double that in the right hand one; both engines use back pressure, one to a reasonable, the other to an unreasonable extent, the one has just double the percentage of back pressure in power to total load of the other engine. Both engines are nearly the same I.H.P. if back pressure was reduced, boiler evaporation quite in favor of the large engine, calorimetric conditions at boiler not in its favor, but at the engine twenty per cent. to its advantage.

There are many points of interest in this table over which steam-users can ponder. One of them is that the value of the steam, as a means of doing its work again in boiling, etc., is not represented by the amount of water per calorimeter, but that that percentage is a reduction of "heat of vaporization," or, to use Zeuner's formula, if we have steam at eighty-two pounds and 1·8 per cent. of water, we lose 95 heat units from each pound of steam, and eight per cent. of water 148 heat units, and 12·6 per cent. of water in steam of eighty pounds = 183 heat units loss. So in back pressure of ten and one-half pounds gauge pressure, we lose with five per cent. of water 116 heat units, and at forty per cent. of water 431 heat units lost out of 1,141. The users of this "system" advocate latent heat in its entirety, forgetting that water present absorbs latent heat very rapidly. The calorimetric conditions between the two engines are very different in the three amounts cited, while the conclusion shows that the New Hampshire man pays over double for his coal, yet makes his I.H.P. at $16.48, while the Pennsylvania man's horse-power costs $29.45, with coal at half the money or, to put it in another form, give New

Hampshire his coal at $2.20, and he will make his I.H.P. for $8 against Pennsylvania's $29.45, or nearly, or in comparison, if both men used 1,000 horse-power under present conditions, New Hampshire would save a clear profit of $12,970 per year, or if Pennsylvania used 2,000 horse-power only, his coal alone would cost $25,940 more than the New Hampshire man, and if the New Hampshire man had coal at $2.30, he would make his horse-power for $8.24 nearly, and save $21,210 on *1,000 horse-power* over the Pennsylvania man each year.

WHAT DOES A STEAM HORSE-POWER COST?—NO. 8.

An Instance of Pumping Machinery.

Cost of coal, per ton,	$2 40
Pounds of water per I.H.P. of work per hour,	815·82
Boiler pressure,	80 pounds steam gauge
Initial pressure,	36 pounds, absolute
Back pressure,	21 pounds, absolute
Ratio of back pressure to whole load,	78 per cent.
Steam engine required,	4·7955 times the work
Work actually done,	6·5238 horse-power of steam
To do,	1·36045 horse-power of work
Actual amount of water per I.H.P. steam,	170·52 pounds per hour
Water in back pressure varied from 21 to 40 per cent.	
Cost of one I.H.P. one hour of work, cents,	87·428
Cost of one I.H.P. 308 days of ten hours each as one year,	= $2,692 78
Cost of one I.H.P. one hour of steam, cents,	18·322
Cost of one I.H.P. 308 days of ten hours each as one year,	= $564.32
One horse-power costs more than 75 horse-power Corliss engine, in ordinary circumstances, at	$18\frac{322}{1000}$ cents an hour

So far nothing has been shown, but what a side-by-side comparison was made. In the data now on the screen (No. 8), an instance of how far men can and do go in machinery for using steam needs no comparison.

With coal, at $2.40 per ton, and 815·82 pounds of water per hour for *one* single I.H.P. of steam.

This is not by any means the worst case that could be shown, and the figures will bear thoughtful contemplation. The range of cost for an I.H.P. shown to-night runs from $7.98 per year of 3,080 hours to $564.32, leaving out the one

item of $2,692.78 for one I.H.P. of work for same time. The conditions in each case will account for all the difference.

If time permitted, I could exhibit to you cases of locomotives blowing through steam two and one-half to four times what was necessary; electric light and railway enterprises, with results that would make any man turn pale if his pocket-book was involved; steamships that are outlets for coal mines only, and other and curious facts. Steam will not be displaced under a few years. Compound engines, using sixty to eighty pounds of water per horse-power, non-condensing, and twenty to thirty on ships, will not immediately drive out better work.

The horse-power can be made by an admixture of brains in the coal for $8 for 3,080 hours, with Corliss 200 horse-power engine and a fair boiler, coal at $3 for 2,200 pounds, for twenty-four hours a day, $7.50; and in 1,000 to 3,000 horse-power, coal at $2.20, and not over twelve per cent. refuse, $5.60 to $6.20 a horse-power, if 144 hours a week, or $7 for twelve hours a day.

Thanking you for your courteous attention for so long a time this evening, I will say: "Good-night."

REPORT OF THE U. S. NAVAL BOARD,

WHICH CONVENED AT BOSTON, MASS., FEBRUARY 10, 1890, UNDER ORDERS OF THE HON. SECRETARY OF THE NAVY TO INVESTIGATE THE WELDING PROCESS OF THE THOMSON ELECTRIC WELDING COMPANY.

LYNN, MASS., February 13, 1890.

To the Chief of the Bureau of Equipment and Recruiting, Navy Department, Washington, D. C.:

In obedience to an order from the Honorable Secretary of the Navy, dated January 9, 1890, constituting us a Board "to examine into the process in use by the Thomson Electric Welding Company, of Boston, Mass., for welding metals, and to report as to its desirability and adaptability for naval purposes, and particularly for use on vessels of the Navy," we have the honor to make the following report:

The process of welding in use by the Thomson Electric Welding Company has been fully investigated by the Board, both experimentally by tests made in our presence, and by investigation of the theories and principles involved.

We find that at the present time this process renders it possible, practically, to weld wrought iron, cast iron, brass and copper rods, from the size of the smallest electrical conductors in use for distributing purposes to rods of two and a half inches in diameter, and to weld pipes of larger sizes; to weld dissimilar metals, and pieces of different forms of cross-section; to join by welding the ends of wire cables, and to form welded rings of small or large diameter.

The operations necessary to accomplish these results were performed upon several different welders having holding-clamps to suit the work in hand, and being of graduated capacity; each machine handling samples varying by a multiple of ten in cross-section; and while none of them represent a machine for general use, it would be possible to construct one having removable clamps to suit different classes of work. In this way, a small number of welders could be adapted to a wide range of service.

As regards the strength of articles subjected to this process, in a majority of samples tested (several in our presence) the rupture did not take place in the weld itself, but at a short distance from it, in that portion of the metal which had become more or less affected by the heat. This would occur in the same way in the ordinary process of welding.

As all of the welders are similar in general design, one is selected for description—that of 20,000 watts electrical capacity, whose range in welding is from three-eighths inch to one and a quarter inch bar iron, or three-fourths these limits for brass, or one-half for copper.

THE 20,000 WATTS WELDER.

The principle of the operation of the machine is the heating of a point of contact between two masses of metal, due to the passage of an electrical current across the surface of contact. The current used is alternating, in order to avoid the electrolysis that would take place in any other

than an elementary metal, and thus cause lack of homogeneity and consequent loss of strength at the point of juncture. The alternating current is supplied by a converter, which forms the electrical part of the welder, the primary consisting of many turns of wire, with a difference of potential at its terminals of about 300 volts; the secondary containing but one turn—a massive casting of copper—with a large superficial area to avoid the loss due to lack of penetration of the impulses of an alternating current into the interior of conducting masses. The difference of potential at the terminals of the secondary, on open circuit, is in the neighborhood of one volt, thus making the ratio of conversion in the neighborhood of 300 to 1. The core of this converter, like those used in the ordinary converter system for incandescent lighting, is built up of thin laminated strips of soft wrought iron, insulated with tissue paper. The terminals of the secondary are massive copper blocks over which set copper sliding guide blocks, mounted with steel clamps for securely holding the pieces to be welded.

In the preparation for welding, these are placed with the ends touching (they having been roughly formed slightly convex in order that they shall abut near their centres). The current is then turned on, and as the metal becomes hot and finally soft at the contact, the contacts are approached by pressure applied by screw, winch, lever or hydraulic power, until the whole cross-section is at welding heat, and bulges as in ordinary butt welding. The operation requires from a few seconds to two or three minutes, depending upon the size of the work. The burr is removed either by hammering while hot, or in the lathe when cooled. In no case does the heating extend perceptibly more than about the diameter of the rod on each side of the weld. In case of working with easily oxidizable metals, borax is used as a flux.

The welder complete, including converter, clamps and the necessary mechanical part (which in some forms of the apparatus is replaced by hydraulic machinery), is all contained in a substantial iron frame on a cast-iron base. In

order to make the welder adjustable to different classes of work, it is necessary to be able to control the electro-motive force, and therefore the electrical energy entering the primary. This is accomplished by placing a second converter (having a movable secondary) in series with the primary of the welder. In a segment of a split-ring laminated core, are wound several coils which may be connected in series or multiple by means of a switch. Within the annular ring, is an iron armature, and mounted upon this is a heavy brass casting enclosing the annular core and forming a secondary. If this be placed so that it embraces the primary coils, the drop in them will be double (approximately) that which it would be in case the secondary is revolved to the other side of the ring, thus embracing the slit, across which, practically, no lines of force pass. Thus the E. M. F. absorbed in this throttling device may be varied within wide limits, and vary in like proportion the E. M. F. available at the welder. The electrical capacity of this welder being 20,000 watts, the primary E. M. F. being about 300, that of the secondary about one, the efficiency being in the neighborhood of eighty per cent., the current in the secondary, at maximum work, would be about 16,000 ampères. Thus the engine horse-power necessary for this size work is about thirty. It is stated by the electricians of the company that a weld in two and a half inch round bar iron requires about 140 horse-power at the engine. The fact that all parts of the apparatus remain remarkably cool indicates its excellent design.

The dimensions of this machine are: weight, 2,000 pounds; height, 34 inches; floor space, 27 x 7 inches.

We are convinced that the Thomson Welding Process can be found of great utility to the naval service, both on shore and afloat, for the following reasons:

It can be used—

(*a*) In welding breaks in rods without altering them either in length or shape.

(*b*) For welding tubes.

(*c*) For welding angles and shapes of intricate form.

(*d*) For welding copper, brass, cast iron or other metals.

(*e*) For heating metals for forging, tempering and upsetting.

(*f*) For welding wire cables.

Under these heads the following may be mentioned as a few of the many applications that would result on shipboard; for welding broken pump piston-rods, valve stems, etc.; for joining wires of iron, copper or other metals or bars of the same, of similar or different shapes or sections; for making joints at angles with bars (T or Y-joints); for mending chain and wire rope; for constructing or joining, end to end, pipe of all kinds, and of large or small diameter; working or joining lead pipe; welding T-connections or elbows into lines of piping; welding safe ends to boiler tubes; repairing boiler tubes; welding eye-rings, and welding these again to bolts or bars; repairing cutting and boring tools without hurting their temper; lengthening or shortening rods or bars; repairing broken cast-iron pieces of machinery or broken cast iron or cast-brass fittings; welding copper electric mains.

This system of welding thus renders easy many operations in the working of metals which with the forge and smith have heretofore been considered impossible.

It is the unanimous opinion of the Board that in the present day of ships constructed almost entirely of metals, and in which every fitting possible is made of metal, such a system as that which has been investigated by us becomes not only desirable, but also a means to economy of expense, time and labor, and would add to the efficiency of the vessel under any condition of service.

This system of welding occupies a position of its own; it is able to do not only a large part of the work of the forge now in use, but also is capable of doing much work that was hitherto considered impossible. By its use, the large accumulation of now almost worthless boiler tubes stored at the navy yards could be made fit for service; and the quantity of spare tubes and of many other stores now carried by ships could be reduced.

As the classes of work at naval stations and on shipboard differ materially, the welders designed for use in the two

places should be constructed for the work that will be required of them; those for use on board ship being especially designed with a view to lightness, compactness and adaptability to general work.

THE ALTERNATING CURRENT GENERATOR.

The alternating current generator used in connection with this electric welding system is a multipolar (having four poles), self-exciting dynamo, or with separate exciter, if desired. The electro-motive force is somewhat above 300 volts; the number of alternations, 6,000. The armature has four coils which are wound on the surface, around heavy projections on the core, each coil covering 90° of the surface of the cylinder.

The armature core is built up of laminæ of soft wrought iron, insulated by tissue paper, the whole being set together under hydraulic pressure between cast-iron headers. Longitudinal holes are bored through the core to allow of ventilation of inside, and the field magnet cores and pole pieces are laminated in order to prevent heating in them, owing to the eddy currents that would be set up by the motion of the heavy core projections on the surface of the armature. Though the field magnets are not compound wound, advantage is taken of the properties of the alternating current to vary the portion of the current, commutated in such a way as to procure either a constant electro-motive force at the poles of the machine under all loads, or to cause it to rise to any desired percentage with the load in order to compensate for drop in the circuits. The dimensions of the machine are: height, 46 inches; floor space, 50 x 31 inches; weight, 1,550 pounds.

The machine might be used in an emergency for lighting purposes. By having it built for the standard E. M. F. of the service, it would be able to supply lights in a detached section or in the whole ship, when the number of lights in use did not exceed its maximum capacity. The dynamo could be built as a direct driven machine, and, output for output, would not greatly exceed the standard machines of the service in size and weight.

The generating dynamo, which supplied the energy for all the welders tested, was also supplying current at the same time to seventy-five sixteen candle-power incandescent lamps arranged in series groups of five each. These gave a steady light, with the exception of a momentary increase in brilliancy, due to the electro-motive force of self-induction on breaking the circuit of the larger welders. The dynamo being self-regulating, the lamps have the proper difference of potential at their terminals under all loads within the capacity of the machine. Of course, with a machine built for the standard electro-motive force of the service, current would simply be supplied to the lamps in parallel, as in the present system of lighting.

These dynamos could not replace the continuous current machines now in use, as motor work on shipboard is a widening field, and there is, as yet, no electric motor of greater power than a small fraction of a horse-power that can be run on such an alternating circuit. Neither could the search lights be worked from such a machine. On the other hand, it would be impracticable by any modification of the existing continuous current dynamos, or by the addition of a pulsating device in the circuit of the continuous current, to adapt it to the circuit of the welder, and thus avoid the special generator that must be a part of the installation for welding.

In illustration of the apparatus used, a set of photographs, giving dimensions and other data, is inclosed.

Very respectfully, your obedient servants,

Commander GEORGE A. CONVERSE, U.S.N.,
Senior Member.

A. S. GREENE, U.S.N.,
Member.

Asst. Naval Constructor S. W. ARMISTEAD, U.S.N.,
Member.

Ensign GILBERT WILKS, U.S.N.
Member.

THE METALLURGICAL ARTS AT THE PARIS EXHIBITION.

BY F. LYNWOOD GARRISON,
Delegate of the INSTITUTE.

[*Continued from vol. cxxix, p. 517.*]

MANUFACTURE OF CEMENT AND CRUCIBLE STEEL.

Prof. Jordan states that the use of *cementation* or *converting furnaces* is somewhat stationary in France. There were, in 1877, thirty-four converting furnaces with an output of 1,717 tons of cement (blister) steel; in 1889, the number of working furnaces was twenty-four and the output was 1,491 tons.

These furnaces are not employed solely for the carbonizing of superior wrought-iron bars, intended for the making of shear steel or tool cast steel; they are also used for adding carbon to certain puddled steels and even to certain cast steels for special purposes.

In reference to *crucible steel*, the official statistics give, for 1877, 101 furnaces with an output of 7,252 tons; and for 1887 only thirty-nine furnaces (containing 501 crucibles) have produced 7,532 tons. The old furnaces, heated by coke fires, and containing two or four crucibles each, are now to be found in a few inconsiderable works; the large steel works employ actually nearly everywhere large Siemens gas furnaces, containing twenty and even forty crucibles.

THE IRON AND STEEL WORKS OF FRANCE

may be divided into four groups—the North, with such works as Anzin, Denain, Valenciennes, Maubeuge; the Centre, with Creusot, Commentry, St. Chamond, Firminy,

Unieux, St. Etienne, Fourchambault; the South, with La Voulte, Bessèges, St. Louis; and the East, with Longwy, Pont-a-Mousson, Stenay and St. Dizier.

In treating the French iron and steel works more in detail, I will not confine myself to describing the exhibits of these works, but will endeavor, as far as my means will allow, to give a more or less descriptive account of some of the most important of these works themselves. Some of the largest works in France, notably Creusot, were not at all represented at the exhibition; it would, therefore, seem obviously a mistake in a report of this kind, to omit to make any mention of such large and important establishments. As I have previously intimated, not having received any official recognition from the French exhibition officials, I have been greatly hampered in collecting reliable and accurate details for the report. I need not, therefore, offer any further excuse for the meagreness of detail with which I have been obliged to treat some of the most important iron and steel establishments in France. The greatest number of large establishments are located in the Centre, in what is known as the Loire Basin. We will, therefore, begin with the most famous, if not quite the largest of these Loire works:

LE CREUSOT.

The Creusot establishment is one of the oldest of all the large steel works in France. Its beginnings were very small; a century ago the spot where these works now stand was a small hamlet of fifty inhabitants, called La Charbonière. In 1782, a small gun foundry was erected there by Louis XVI, and, at a somewhat later period, four blast furnaces were erected. This was one of the first establishments in France at which Watt's steam-engine was used. The importance of Creusot was greatly enhanced, in 1793, when the Canal du Centre was opened, for prior to that date its means of communication with the rest of France were very imperfect. The wars of the First Napoleon created a great demand for guns and projectiles, and Creusot received a fair share of the contracts, thus giving it, until the time when

peace was restored, in 1815, a very large amount of work. The works passed through several hands until 1836, when they were acquired by MM. Schneider Frères & Co., who have owned them ever since, M. Henri Schneider, son of M. Eugène Schneider, one of the original firm, being now at the head of the establishment.

With the introduction of railroads in France, the Creusot Works developed rapidly. Under the superintendence of M. Bourdon, the first steam-hammer was constructed there, and by this means the works were enabled to construct marine engines. During the Crimean War, Creusot turned out seventeen 150 horse-power gunboat engines in seven months.

Shortly after 1860, the plant was much enlarged and improved, new blast furnaces were erected, and an annual output of 150,000 tons of iron was effected.

The Creusot Steel Works date from 1869. In the second part of the war of 1870–71, the works supplied the Government, in the course of five months, with twenty-three batteries of seven guns, on the Reffye's system, made of bronze and two of the same of steel; also, sixteen batteries of Reffye's mitrailleuses; in all, 250 guns and fittings.

Messrs. Schneider & Co. control a number of works, etc., in various places besides Creusot: the collieries of Montchanin and Longpenou (Saône-et-Loire), those of La Machine, near Decize (Nièvre), and Montaud-Saint-Etienne (Loire); the iron mines of Mazenay (Saône-et-Loire), of Laissey (Doubs), Allivard (Isère), and St. George's (Savoy). The ship-yards at Chalon (Saône-et-Loire) and the fire-brick manufactory at Perreuil (Saône-et-Loire). Messrs. Schneider are also interested in the collieries of Beaubrun (Loire) and Brassac (Puy-de-Dôme), in the iron works of Jaeuf (Meurthe-et-Moselle), and in the ship-yards of La Gironde, Bordeaux.

In 1837–38, the entire output of coal from the Creusot works was 60,000 tons and 5,000 tons of pig iron; in 1880–81, it was 579,000 tons of coal and 173,000 tons of pig iron, the production of iron and steel and shop work increased in a proportionate amount.

During the financial year of 1880–81, the consumption of materials amounted to 621,000 tons of coal, 200,000 tons of

coke and 517,000 tons of iron ore. When the whole works are engaged to their full capacity, they are capable of an annual production of 700,000 tons of coal, 200,000 tons of pig iron, 160,000 tons of iron and steel, 30,000 tons of machinery and 30,000 tons of bridge material.

The aggregate area occupied by the works, including stores, gardens, etc., is said to be about 1,000 acres. The works employ 15,500 hands, all told, and 180 miles of railroad, used exclusively for the requirements of the establishment.

It has been claimed that Creusot produces the best armor plate in the world, and judging from the results of some of the recent competitive armor-plate tests, this claim seems well established. Since 1876, when Messrs. Schneider obtained a large contract from the Italian Government, the works have produced 25,000 tons of armor plate, and at present they have sufficient plant to turn out 6,000 tons every year. Some of the plates made at Creusot weigh no less than sixty-five tons. They are at present engaged in manufacturing a number of turrets for the French and Belgian Governments.

The Creusot works, since 1873, have supplied ordnance of various descriptions to the French, Italian, Spanish, Japanese, Chinese and United States Governments, stated to amount to several hundred guns and mortars, ranging from three to sixteen inches in diameter and upwards of some 800,000 shells and other projectiles. The first De Bange guns, of from three to three and one-half inch bore, were made at Creusot. In 1888, the new gun foundry was completed, having facilities for producing guns weighing as much as 120 tons. Some of the largest forgings made at these works were the *hollow* shaftings for the *Magenta*, sixty two feet four inches in length.

Great attention is given to the manufacture of marine engines at Creusot and many of the best ships in the French Navy and Merchant Marine are fitted with their engines; they are at present (1889) building a 12,000 horse-power set for the armored ship *Magenta* and a number of other sets of less power. The aggregate horse-power hitherto built at Creusot amounts to 257,000. At their ship-yards, at Chalon-

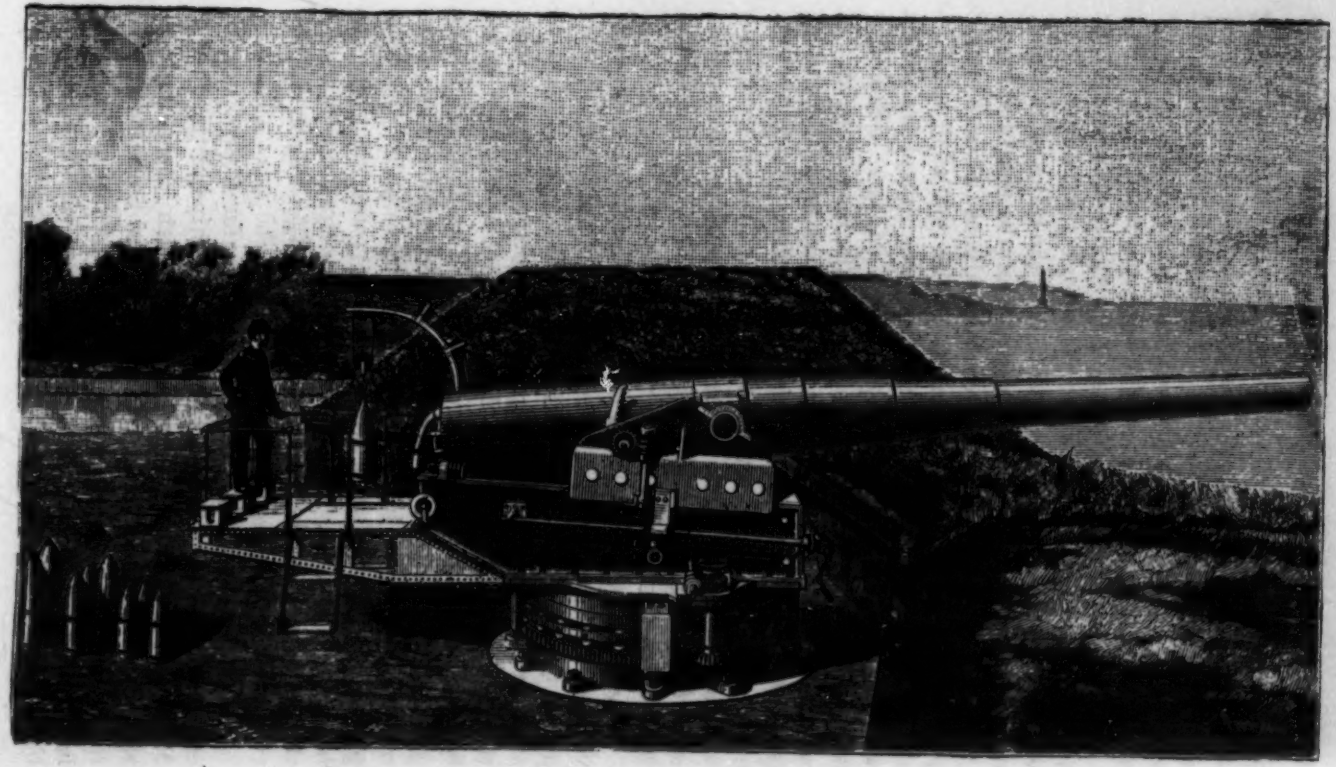


FIG. 1. Twenty-four Centimetre Creusot Gun.

FIG. 1. Twenty-four Centimetre Creusot Gun.

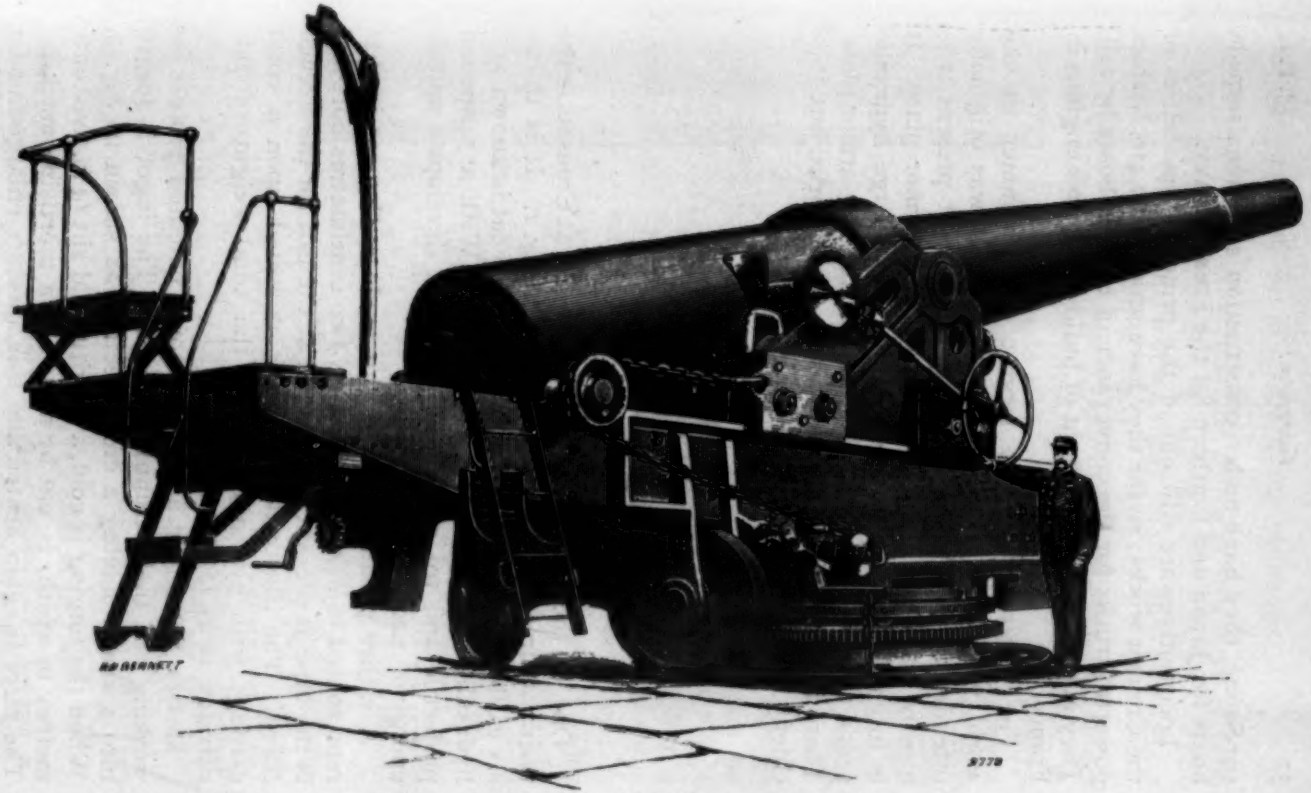


FIG. 2. Thirty-two Centimetre Creusot Naval Gun.

sur-Saône, they have under construction seventeen torpedo boats for Japan and fourteen for the French Navy.

Locomotives are still one of the principal specialties of the Creusot works; so far they have produced 2,416, besides powerful trucks for the conveyance of torpedo-boats by rail. They also have the sole right of building Corliss engines in France.

For several years the largest steam-hammer in the world was the 100-ton one at Creusot; it was originally intended for heavy ordnance forgings, but at present it is mostly employed for the manufacture of armor plate. It is intended shortly to supplement it by a large hydraulic press, such as is used in England for forging armor plate. There is already a 6,000-ton press at these works, but it is chiefly used for bending heavy plates.

FIG. 3.

One of the best types of guns made at Creusot is the twenty-four centimetre, represented in *Fig. 1*. It is thirty-six calibres in length and is mounted on what is known as a hydraulic, central pivot coast carriage. With a 348-pound projectile and 191 pounds of powder it develops a muzzle energy of 2,200 feet per second.

A rather peculiar type of gun made at Creusot is that represented in *Fig. 2*. It is thirty-two centimetres bore and is the type at present constructed at Creusot for the French Navy. The illustration shows it mounted upon a coast carriage with hydraulic brake; the total weight of this carriage is 45,227 kilos.

Messrs. Schneider use at Creusot a patented process for working out their trunnion hoops. The ingot is forged into a shape having a cross section, as shown in *Fig. 3*. When the forging is cold, a longitudinal slit (*a b*), five-centimetres in width, is cut by means of a mortising machine. The piece is again heated and this aperture enlarged under

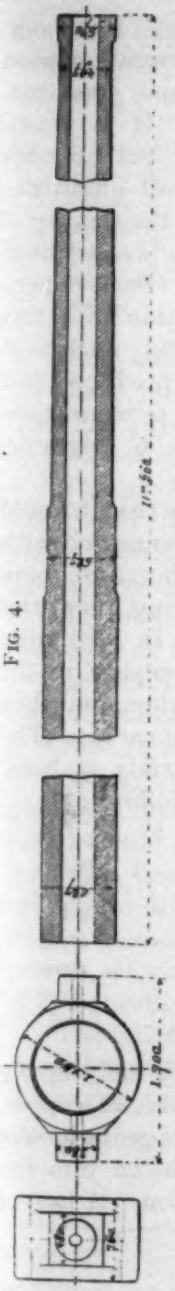


FIG. 4.

the hammer and brought to a circular form by means of appropriate mandrels. The hoop, when turned, bored and finished, is shown in *Fig. 4*.

Creusot Copper Steel.—Messrs. Schneider have patented a process,* which consists in making in a blast furnace, a cupola or a reverberatory furnace, castings containing a variable amount of copper with a less variable proportion of the ordinary elements. These castings are used for the manufacture of copper steel for armor plate, ordnance, projectiles, steam cylinders, etc., these articles being hardened or tempered in oil.

The copper ore is mixed with the charge in the cupola, or else copper filings can be mixed with the coal to form a copper coke which is then used in melting the iron in a blast furnace or cupola. Copper compounds may also be melted in a reverberatory furnace, with a mixture of iron or steel under a layer of anthracite to prevent oxidation.

This subject is one of so much importance that it deserves the most serious attention, and it has been deemed expedient to reprint in this connection the following article which was recently published in the *Journal of the Iron and Steel Institute*:†

"It has long been a matter of discussion whether true alloys of copper and iron can be produced, and great divergence of opinion has existed as to the influence exerted by small quantities of copper on the mechanical properties of iron and steel. As evidence on this point, attention may be

* English patents, 16,568 and 16,569. 1888.

† "Influence of Copper on the Tensile Strength of Steel." By Edwin J. Ball and Arthur Wingham. No. 1. 1889. p. 123.

drawn to the views expressed by Mushet, Rinmann, Berthier, Karsten, Willis and Percy, the general opinion appearing to be that copper renders iron and steel red-short. Jars,* writing in 1774, observes: 'It is generally thought that copper is a pest for iron,' but he adds that he had been told by Cramer, that small quantities of copper had been found by him to improve the quality of iron, and that even one per cent. could be added without destroying the welding power of that metal. Such experiments as have hitherto been made in connection with this subject were but imperfectly supported by analytical evidence as to the composition of the alloys produced, but the earlier of the experiments above referred to were made before the necessity of submitting metals to rigorous mechanical tests was well understood.

"This divergence of opinion led us to believe that it would be interesting to obtain some definite results connected with this subject. A series of experiments was, therefore, instituted to ascertain the effect produced by varying quantities of copper on the tensile strength of steel. In beginning these experiments, it appeared desirable to prepare, in the first place, an iron rich in both copper and carbon, and then to alloy this with a metal containing but little carbon. The metal chosen for the latter purpose was a variety of basic Bessemer steel, the analysis of which was as follows:

BASIC BESSEMER STEEL.

	Per Cent.
Copper,	none.
Carbon,	0·133
Manganese,	0·284
Silicon,	0·002
Phosphorus,	trace
Sulphur,	0·06

"The iron, rich in copper, was produced by melting pig iron, and then adding to the molten metal oxide of copper. The carbon and silicon acted as the reducing agents for the cupric oxide, and the copper was thus introduced into the iron by a 'reaction,' and not by simple solution. A part of

* *Voyages Métallurgiques*, Lyons, 1774, vol. i, p. 4.

the other impurities in the pig iron was also burnt out in this manner, and a metal (A) was obtained which had the following composition:

METAL A.

	Per Cent.
Copper,	7·550
Carbon,	2·720
Manganese,	·290
Silicon,	·036
Phosphorus,	·130
Sulphur,	·190

"This metal was bright, white in color, crystalline, and very hard, but it did not offer any great resistance to impact. Varying quantities of it were then melted down with the basic Bessemer steel previously mentioned.

"The products of these fusions were allowed to cool very slowly, the crucibles in which the fusions had taken place being permitted to remain in the furnace until quite cold. Test-pieces, 1 x $\frac{1}{4}$ x $\frac{3}{16}$ inch, were then cut, and submitted to tensile tests in a multiple lever testing machine, the test-pieces being first carefully annealed.

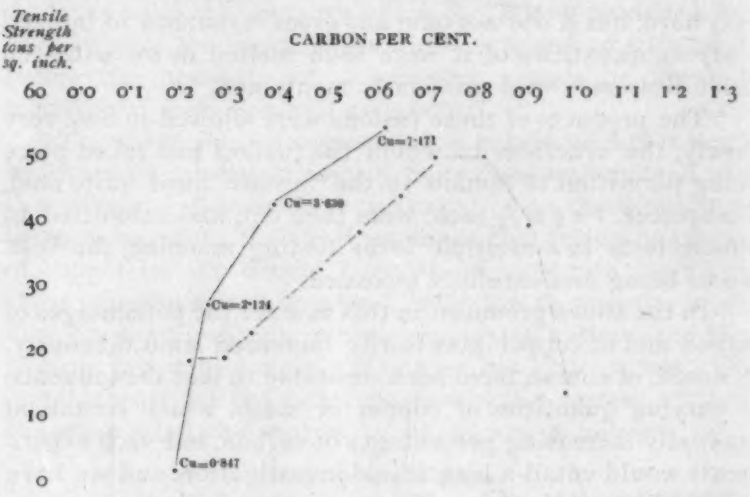
"In the alloys produced in this manner the percentages of carbon and of copper necessarily increased simultaneously. It would, of course, have been desirable to test the influence of varying quantities of copper or steels which contained gradually increasing percentages of carbon, but such experiments would entail a lengthened investigation, and we have therefore, considered it sufficient, in this preliminary examination, to obtain evidence as to the influence of copper on iron in the presence of gradually increasing quantities of carbon, which might form a basis for a further examination of the question.

"The following table shows the percentages of copper and of carbon in the metals tested, and the results of the tensile tests of the various specimens:

Test-Piece. No.	*Copper. per cent.*	*Carbon. per cent.*	*Tensile Strength. tons per square inch.*
1,	0·847	0·102	18·3
2,	2·124	0·217	36·6
3,	3·630	0·380	47·6
4,	7·171	0·712	56·0

"The total elongation of the test-pieces was also noted, but owing to their small size the results are not trustworthy. The elongations observed, however, were as follows: Test-piece (1) ten per cent.; (2) five per cent.; (3) five per cent.; (4) showed no visible extension, or the extension was but very slight.

"In the following table are shown, in the form of a curve, the tensile strengths given above, as well as those which are considered by Mr. R. Gatewood* to represent the strengths of ordinary steels of varying degrees of carburization, the latter curve being shown by dotted lines:



"It will be observed that the tensile strengths of the specimens containing copper are greater than those of the specimens in which no copper is present. Where the turning-point of the curve would be in the case of the cupriferous series, we are unable to say, as other samples which were prepared, and which contained more carbon than the above, were so hard that test-pieces could not be cut. That copper increases the tensile strength of iron is also apparent from the following results:

* *Journal of the Iron and Steel Institute*, 1887, vol. i, p. 444.

Description.	*Copper. per cent.*	*Carbon. per cent.*	*Tensile Strength. tons per sq. inch.*
Original steel.	—	0·133	29·0
Test-piece 5, ...	4·10	0·183	43·2
Test-piece 6, ...	4·44	trace	34·3

"This latter metal did not, however, appear to be perfectly homogeneous, and it was observed throughout these experiments that the simultaneous presence of carbon appeared greatly to assist in the more intimate association of the copper with the iron in which it was dissolved.

"Observations of the fracture showed that of test-piece 1 to be somewhat fibrous, whilst those of 2 and of the remaining samples were highly crystalline. The fracture of sample 6, which contained no carbon, was very irregular, the metal being of a bright gray color and highly crystalline. The fracture of specimen 4 was very finely granular and close.

"Besides determining the tensile strengths, forging tests were also made. Some of the specimens, comparatively poor in copper and carbon, appeared to forge fairly well both cold and hot, and this was the case with specimens 1, 2, 3 and 5. No. 4 forged well in the cold, but was red-short, which is to some extent in accordance with the views expressed by the older writers. The results cannot, however, be considered very reliable, owing to the small quantity of the material that was at our disposal for the purpose of these tests. The principal effect that the presence of copper appears to exert on iron and steel is to render it extremely hard. This was peculiarly evident in the case of specimen 6, which was free from carbon, but contained 4·44 per cent. of copper, and was so hard that it could scarcely be cut by a good hack-saw. Owing to this great hardness, and to the comparatively good results of the forging and tensile tests, we hope that further tests of the crushing strengths of these metals may lead to the results being of interest from a practical point of view.

"The opportunity afforded by the preparation of the metal A was taken for observing the order in which the carbon, sulphur and silicon originally present in the pig iron were eliminated by the oxygen of the cupric oxide added,

the percentage of sulphur in the metal having been largely increased for the purpose of this experiment, which consisted in melting the iron in a graphite crucible, and then making successive additions to it of cupric oxide. After each addition of the oxide, the metal was poured, a sample taken for analysis, and the remainder charged into the crucible again and remelted, a further addition of cupric oxide being then made.

"The following table shows the composition of the pig iron used, as well as that of the samples taken after each successive addition of cupric oxide:

Description.	*Silicon, per cent.*	*Carbon, per cent.*	*Sulphur, per cent.*
Pig iron,	1·02	2·60	1·44
First sample,	0·55	2·32	1·27
Second sample,	0·10	2·02	1·12
Third sample,	0·05	1·77	1·18
Fourth sample,	trace	0·61	1·08
Fifth sample,	trace	0·34	0·85

"It will be observed that whilst the silicon was rapidly oxidized, the carbon was only appreciably attacked after nearly the whole of the silicon had been eliminated; and, further, that the percentage of sulphur was not greatly affected till most of the carbon had been burnt off. This diminution in the percentage of sulphur may, however, to some extent be accounted for by the dilution of the pig iron by the copper reduced from the cupric oxide.

"From a general consideration of the results of our experiments, it would seem that within certain limits copper does not prejudicially affect the mechanical properties of steel, and this to some extent agrees with the theory recently put forward by Prof. Roberts-Austen,* and supported by much experimental evidence, that small quantities of a metallic impurity only exert a deleterious effect on a large mass of another metal if the atomic volume of the impurity is greater than that of the metal in which it is hidden; and that if the atomic volume is either about the same or smaller, it will either exert no appreciable dele-

* *Proceedings of the Royal Society*, vol. xliii, 1888, p. 425.

terious effect, or else act as an improver. The atomic volume of copper is nearly the same as that of iron. In our experiments, however, the percentages of copper were considerably higher than those which Prof. Roberts-Austen contemplates."

COMPAGNIE ANONYME DES FORGES DE CHATILLON ET COMMENTRY.

This company was founded in 1845, has a capital of 12,500,000 francs and is stated to have no funded indebtedness whatsoever. They have blast furnaces, steel and construction works at Montluçon-Saint-Jacques (Allier), blast furnaces and mills at Commentry (Allier), blast furnaces at Beaucaire (Gard) and at Villerupt (Meurthe-et-Moselle), rolling mills, wire and nail works at Sainte-Colombe, Ampilly, Mussy and Chamesson (Côte-d'Or), Plaines (Aube), Morat (Allier), Vierzon (Cher), and a wire-rope manufactory at Français (Allier). The company have besides collieries, iron mines and quarries at various places. The range of their products includes almost every article made of iron or steel, but, like all the great steel works in France, they made a specialty of war material. Since 1867, they have supplied the French marine with very large quantities of iron, steel and compound armor plates and to the French and Belgian Governments a number of large turrets for the armament of forts.

The Châtillon et Commentry Company's exhibit was in two parts. The part devoted more exclusively to commercial products was in the same section as the exhibits of the other iron and steel works of the Loire Basin, whilst that of the war material was in the pavilion of the Minister of War. The display of commercial articles was extensive and interesting, consisting of angles, beams, tires, wire rope, wire nails, etc. A fine lot of excellent steel castings of various sizes were also shown. By far the most interesting part of the exhibit was that of the war material. Since 1867, the Châtillon et Commentry Company have given special attention to armor plate. In 1880, when compound armor was adopted by the French Navy, this company was one of

three French concerns who acquired the right to make what was known as the "*Cammell compound plates.*" The company, however, does not confine itself to compound plates, as *all-steel* plates are now receiving the most serious attention. A portion of the exhibit in the pavilion of

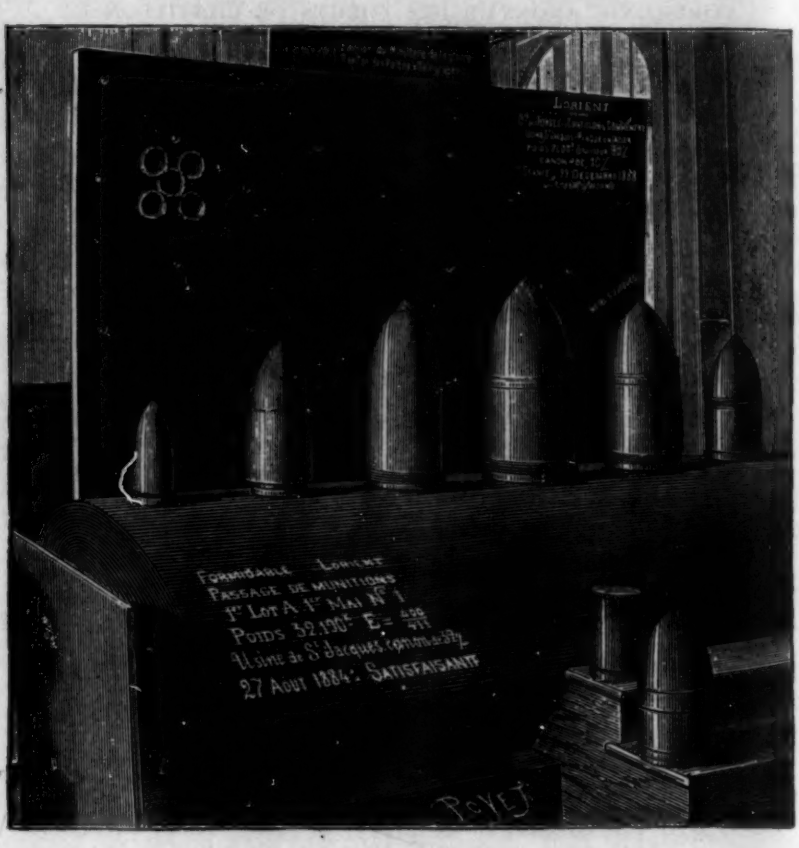


FIG. 5.

the Minister of War is shown in *Fig. 5*. *Fig. 6* shows part of an iron plate, one-half metre thick, weighing 34·6 tons, tested at Gavres, in 1886, giving the most satisfactory results. In *Fig. 5* is shown a compound plate made for the *Formidable*, weighing 32·19 tons, tested in 1884 with satisfactory results.

The Châtillon et Commentry Company have made a specialty of soft and extra soft steel plates, to be used where glancing shots are apt to strike.

Perhaps the most interesting development which this company has recently made in the metallurgical art is the *process of tempering steel in molten lead.*

Cie des Forges de Chatillon & Commentry
Usines de St Jacques
Plaque de Fer pour Muraille D'epreuve
Poids 34.000k
7 Mai 1886
Tres Satisfaisante

FIG. 6.

For many years it has been a somewhat common practice to use baths of the easily fusible metals or alloys for quenching steel, but never before has it been attempted on so large a scale as at present in use at the works of this company. An excellent article on the subject of tempering in molten lead at the Châtillon et Commentry Company's works, was published in a recent issue of the *Iron Age;** it

* October 10, 1889.

was thought of sufficient interest to present the following data from the same:

The company has established a special plant for this purpose, and has experimented exhaustively and intelligently on the subject. In a special report by M. Evrard, General Manager, it appears that the size of the lead-bath has been increased, until now it is capable of holding 250 tons of lead. The temperature is varied considerably according to the kind of steel operated on, and the depth and volume of the bath must be changed, which it seems is done by filling in parts of the space otherwise occupied by lead. From the report of M. Evrard and articles by E. Lisbonne in the *Génie Civil*, we gather the following data:

Starting on hammered steel, shells made of steel carrying about one per cent. of carbon yielded the following results, bars being cut from the cold metal:

	Limit of Elasticity. kg.	*Tensile Strength.* kg.	*Elongation.* per c nt.
Tempered in lead:			
No. 1, ...	50	81	9·5
No. 2, ...	47	84	9·5
No. 3, ...	48	91	7·75
Average, ...	48·4	85·4	9
Tempered in oil:			
No. 1, ...	47	83	6
No. 2, ...	45	73	7·5
No. 3, ...	44	73	6
No. 4, ...	45·4	85·4	6·5
Average, ...	45·4	76·4	6·5

Shop-tests were carried on on bars 30 x 30 cm. placed on supports 160 mm. apart, an 18 kg. trip-hammer being used. The distance of the fall was increased at each blow 10 cm., starting at a height of 50 cm. In the case of the steel tempered in lead, rupture resulted at a height of 2·80 m. in the two first cases, and 2·40 m. in the second, while in the case of shells tempered in oil the figures were 2·10 m., 2·20 m., 1·90 m. and 2·07 m.

On gun tubes which were made at the works from soft steel the process does not seem to give a notably better result than that used in ordinary manufacture. It simply has the advantage of doing away with reheating.

The first experiments made by the Commentry Company on armor was on parts from two plates carrying 0·54 to 0·64 of carbon. In the case of the former the resistance from rupture rose from 6·2 kg. to 7·6 kg., and the elongation, which was 15·5 per cent., dropped to 9·5 per cent. In the case of the steel containing 0·64 carbon, the resistance rose from 77.3 kg. to 88 kg., and the elongation, which was 10·5 per cent. before tempering, was 13 per cent. after it. On compound plates the steel of which carried 0·73 carbon, the plate merely reheated showed an elastic limit of 39 kg., a tensile strength of 80 kg., and an elongation of 10 per cent. When tempered in lead the elastic limit rose to 58 kg., the tensile strength to 95 kg. and the elongation to 12 per cent. On soft steel-plates two specimens carrying 0·30 carbon showed the following: The limit of elasticity was increased from 25·7 kg. to 28 kg., the tensile strength from 5L4 kg. to 53 kg., while the elongation was reduced from 25 per cent. to 23 per cent. M. Evrard states that in all soft steels which have been rolled there is very little increase of resistance from the tempering by lead. The most notable result is an increase of the ballistic resistance, as was proved by our trials with guns which we will mention further on. He claims, however, that on soft steels merely cast, immersion in metallic baths has a most marked effect. The grain is as completely changed as if it were done by forging, and resistance to shock is increased to a notable degree. Our ballistic experience on merely cast and tempered plates give about the same results as those on rolled plates. He urges that herein lies one of the most important applications of the process to the manufacture of armor plates, and besides to all kinds of cast metal, on account of the increase or resistance due to the use of this method of tempering.

The first experiments of the target practice at the Sainte-Jacques Works were all made under identical conditions so as to facilitate comparison.

The plates tested measured 1·500 x 0·735 and 0·726 m. The cannon used was of 95 mm. calibre, firing at a speed of 416 m. cylindrical projectile, with blunt cone point of chilled iron or chrome steel, weighing 11·4 kg. The shots were fired at

the four corners of a lozenge-shaped plate, whose sides were twice the length of the calibre—*i. e.*, 19 cm. After the first four shots, the remaining shots were fired on the same four spots in the order of the first firing.

The results of these experiments were as follows: An iron plate which was tested as a sample gave a mean depression for the first four shots of 132 mm. and for the following shots of 198. It was cracked by the seventh shot and completely broken in two by the eighth shot. A hard steel plate tempered in lead showed a mean depression of 99 mm., while a non-tempered steel plate showed 105 mm. The number of shots, before rupture, was six for the first and only five for the second, but this result for the tempered plate must be attributed to a lateral flaw which occasioned a premature crack, otherwise it would undoubtedly have stood eight or more shots. Two rolled plates of soft metal showed about the same depression (111 mm. and 112 mm.); only the first was able to withstand one more shot. It was broken by the seventh shot and the second by the sixth. A plate of simple cast steel tempered in lead gave the same results as the rolled and tempered plate. It withstood seven shots, with a depression of 113 mm. A cast and non-tempered plate, tested for comparison, broke at the fifth shot with 119 mm. depression. Two compound plates, tempered and not tempered, presented about the same results as to depression (89 mm. and 83 mm.); the tempered plate stood ten shots and the trial was only stopped by the crumbling of the outer layer of the plate, which was badly welded. The plate not tempered, made of extra-hard steel, broke at the third shot.

The first trials prove very forcibly the influence of the process on the manufacture of armor plates, especially those of hard steel; resistance to penetration and stiffness are increased without any resulting brittleness in the metal. With pieces in soft metal merely cast, we are able to obtain a resistance equal to that of forged pieces.

The company have tried to determine the influence of the process of immersion on metal, independent of their ultimate use. For the tests bars were cast into uniform

shapes, 120 x 120, which were then rolled into blunt cones, 40 x 40. Each metal bar thus used was tempered in a lead bath, at about 400° C., the bath being composed of about ten times the weight of the bar immersed. The temperature of the bars varied according to the nature of the steel, but efforts were made to keep it a little above the point B of the Chernoff classification. The other part of the bar was reheated in the ordinary manner, *i. e.*, two hours red-hot, then cooled in dry sand. Next, the bars, which had served for the tensile strength and shock tests, were cut from the cold metal. These tests were applied under the ordinary rules governing the artillery service, and were made on five different kinds of steel--carbon, silicon, manganese, chrome and cement steel. These experiments established the following facts:

(1) *Carbon Steel.*—Even for this class there is quite an increase of the limit of elasticity. This increase goes as far as thirty per cent. For the harder metals it is generally less, and is about twenty or twenty-five per cent., except for the carbon and manganese steels, where it attains forty per cent. In the soft steel the diminution of elongation is imperceptible. In metals having from 0·45 carbon there is a mean result of thirty-eight per cent. elongation before tempering, varying from ten to fifty per cent. In the shock-test there is an increase of stiffness in the metal according to its hardness. The brittleness after tempering is less, while the tempered bars withstand more shots than those not tempered.

(2) *Silicon Steel.*—Only a few tests have been made with this class of metal. The limit of elasticity, however, after tempering, shows an increase of seventeen to thirty-two per cent. The increased tensile strength is about sixteen per cent. The diminution in the ductility is thirty per cent.

(3) *Manganese Steel.*—The increase of the limit of elasticity after tempering varies from twelve to seventeen per cent. The increase in resistance is from sixteen to twenty-three per cent. The diminution of elongation attains fifty-three per cent.

In the manganese as in the silicon steel, the tempering

by lead increases its stiffness in the shock tests. The number of hammer strokes withstood is about the same for the tempered as for the metal not tempered.

(4) *Chrome Steel.*—In this class of metal the bars tempered were reheated to a dull red. For the most part it was impossible to get at the limit of elasticity after tempering, but it seemed to increase from ten to eighteen per cent. The tensile strength presents a relatively small increase as compared with the preceding metals. This fact is explained by the reheating after the tempering. This increase varies from ten to twenty-two per cent. for widely differing classes of the metal. As for the diminution of elongation, it is less than for the foregoing metals. It is about twenty-one per cent. In the shock-test a noticeable increase of stiffness was observed. The steel after tempering is less brittle and withstands before rupture a greater number of hammer blows.

(5) *Cement Steel.*—The increase of the limit of elasticity by tempering is twenty-one per cent. The increase of resistance is about seventeen per cent. The diminution of elongation is twenty per cent. less for steel carrying less than one per cent. carbon. In the shock test there is quite a notable increase of stiffness, while the metal does not seem to be more brittle after than before tempering.

It is claimed that the fact was proved that even for the harder steels (providing they were perfect at the start) there was no fear of flaws caused by the process of tempering. A chilled cast-iron shell, with 3·50 carbon, which would not have stood the ordinary tempering with oil or water without cracking, came out of the immersion in lead perfect.

Experiments on steel tires are claimed to have proved the advantages of tempering with lead. By submerging steel tires which had been refused by the principal railroads in the lead bath, it was possible (when they were perfect at the start) to put them in condition to fill all requirements of contract. As an example, tests applied to a lot of steel tires for the Lyons and the Orleans railroads are quoted.

Comparative tests were made on fifteen tempered and fifteen tires not tempered. The test applied was the fall of

a 1,000-kg. hammer, from a height of 10 m., on each tire placed horizontally. These tests gave the following results:

	Tires not Tempered.	*Tempered Tires.*
Rupture, ...	3·6 blows (mean).	4·5 blows (mean).
Depression caused by first blow, . .	98 mm.	74·6 mm.

It is claimed that this shows that the tempering increases the stiffness of the metal and its resistance to rupture. The tires thus treated were in condition to be accepted by the railroad company.

M. Evrard sums up the results as follows: "By the lead-tempering process, under conditions indicated above, a mean increase of twenty per cent. in the limit of elasticity may be counted upon; also an increase of eighteen per cent. in the tensile strength. These increases are more pronounced in the carbon steels than in any other. The minimum of increase was found in the silicon steel series. The diminution of elongation was greatest in steel high in manganese; it was the least perceptible in the chrome steel. As regards the shock test, the stiffness is increased without rendering the metal more brittle. It is from these data that each works must determine for itself the article or articles it manufactures which are most liable to gain by the application of this process of immersion in metallic baths."

The following table of tests of water-quenched, oil-quenched and lead-quenched bars is given by Henry M. Howe, in his work on iron and steel metallurgy, as results obtained by the Châtillon et Commentry Company:

PROPERTIES OF STEEL ANNEALED AFTER DIFFERENT KINDS OF HEAT-TREATMENT—CHATILLON ET COMMENTRY.

Number.	Per Cent. of Carbon estimated.	Tensile strength, pounds per square inch, when annealed after				Elastic limit, pounds per square inch, when annealed (?) after				Elongation, per cent. in 8 inches, when annealed after			
		forging.	quenching in water.	quenching in oil.	quenching in lead.	forging.	quenching in water.	quenching in oil.	quenching in lead.	forging.	quenching in water.	quenching in oil.	quenching in lead.
1	0·10	44,090	51,628	—	—	26,170	35,130	—	—	30	20	—	—
2	0·20	43,379	64,429	48,499	44,375	25,601	48,357	36,979	26,738	34	28	30	31
3	0·30	65,567	80,785	71,256	72,251	36,979	52,340	41,815	43,806	24	21	24	22
4	0·40	70,402	88,039	81,496	74,100	39,112	59,024	53·477	45,939	20	18	22	21
5	0·50	77,941	105,391	98,706	86,190	43,806	72,251	65,567	51,486	21	15	19·5	20·5
6	0·60	85,336	112,360	102,404	89,603	46,935	81,070	70,402	53,193	18	13	17	17
7	0·70	91,026	126,583	113,781	99,559	52,624	88,181	7 ,958	61,138	16	14	14	16
8	0·80	93,870	137,961	119,472	106,671	54,046	92,448	7 ,803	56,891	17	11	13	14
9	0·90	98,137	140,806	123,739	108,093	54,046	93,870	79,647	64,002	16	10	13	15
10	1·00	106,671	153,606	129,428	115,205	55,469	106,671	81,070	69,691	17	10·5	11	15
11	1·10	113,782	163,562	145,072	129,428	56,891	116 627	92,448	79,647	14	7	9·5	12
12	1·20	122,316	170,674	163,562	150,761	64,002	128,005	115,203	98,137	12	8	9	10
13	1·30	1.8,005	180,629	163,562	156,451	69,691	125, 61	116,627	95,292	10	6	9	10

Thirteen sets of one and one-eighth-inch square steel bars, apparently eight inches long between marks, each set being of constant composition, are tested tensilely in four different conditions. These conditions are as follows:

(1) Simply annealed, apparently by slow cooling from dull redness after previous forging.
(2) Quenched in cold water from about W. (b of Chernoff), then reheated to 750° F. (400° C.) and cooled slowly.
(3) The same, except that they are quenched in oil instead of water
(4) The same, except that they are quenched in molten lead instead of water.

The proportion of carbon is approximately that given in the second column, and but little silicon, manganese, etc., is present, *i. e.*, the metal is true carbon steel.

The large universal rolls used for rolling armor plate, at the Saint-Jacques works at Montluçon are shown in *Fig. 7*. The horizontal rolls are one metre in diameter, 5·80 m. long, weighing 30,000 kilos each. They will roll a plate 1·20 m. thick, under ordinary circumstances, and with some modifications a thickness of two metres can be obtained. The standards for housings are 4·30 m. apart and 4·70 m. high. The lower roll is fixed, and the upper one is movable in a vertical direction. The bearings of the lower roll are beneath the level of the floor. The bearings holding the upper roll slide up and down within the standards. This roll is balanced by counterweights arranged below the bed-plate, the action of which tends to bear up the roll; the displacement is regulated by pressure-screws passing through the standards. By this means, the axis of the upper roll can be adjusted at various angles to the horizontal axis of the lower roll; thus, plates can be rolled having an inclined surface on the one side.* Either both ends of the upper roll can be moved together in the ordinary way, or one end may be raised or lowered while the other is stationary; or, lastly, both ends may be moved simultaneously in opposite directions.

Another new feature is an arrangement of the driving pinions which keeps the spindle of the top roll horizontal at all positions. This is effected by using two intermediate pinions, of which the lower one, driven by the bottom roll, runs on fixed bearings attached to the front of the pinion-housing, while those of the second are carried in a curved guide, allowing a small amount of motion concentric to the first pinion. The axis of the second pinion is in its turn connected by radial bars with the bearings of the top-roll pinion, so that the latter is raised or depressed by the setting screw which is similar to those attached to the rolls; the axis of the second pinion slides in and out in the link, and remains in gear with it as well as with the one below. In this way

* An elaborate description of these rolls was published in *Le Génie Civil*, September 21, 1889, pp. 489-492.

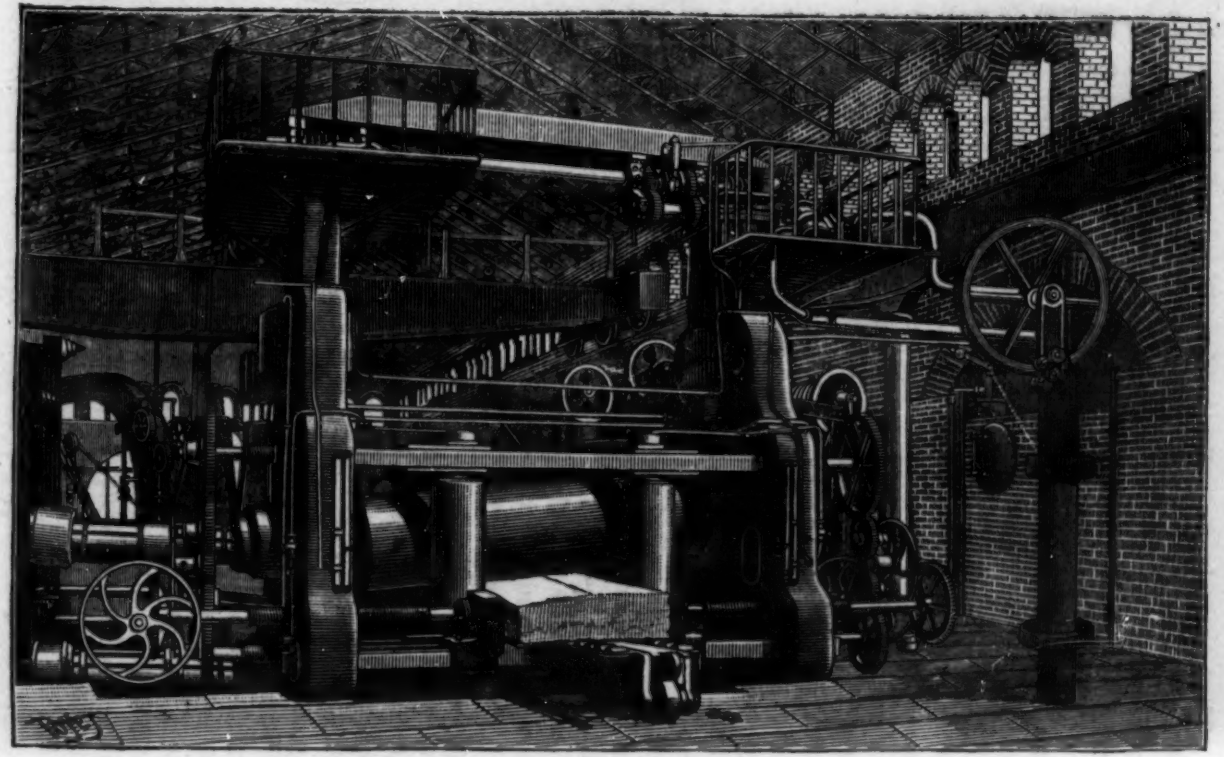


FIG. 7. Universal Rolls for Armor Plates (St. Jacques Works).

the coupling-spindle is kept horizontal throughout the whole range of the top roll, which may be brought down to within a half inch of the bottom one or raised over six feet from it.

[*To be continued.*]

ON SCHOOLS: WITH PARTICULAR REFERENCE TO TRADES SCHOOLS.

By JOSEPH M. WILSON, A.M., C.E.
President of the FRANKLIN INSTITUTE.

[*Continued from vol. cxxix, p. 498.*]

Mechanics.—This is in the list of specific subjects, and in 1884 it was decided to try the peripatetic plan of teaching mechanics in some districts in London. This was commenced in June, 1885, in twenty schools. A lesson is given fortnightly by the science demonstrator, to the boys in the fifth and higher standards, the lesson being illustrated experimentally by specimens and apparatus carried from school to school. Between the visits of the demonstrator, instruction is given to the boys by a teacher who was present at the demonstrator's lesson. In consequence of its success, this plan was extended in 1887, and three additional demonstrators, appointed for three years, as a further experiment.

Kindergarten instruction is used in the infants' department.

Bible instruction is given and religious observances may be carried out, provided, however, always, that the provisions of the acts on public elementary schools, in reference to religious matters be strictly adhered to.

Object Lessons.—As early as 1871 the course of instruction included object lessons, embracing in the six school years a course of elementary instruction in physical science and serving as an introduction to the science examinations conducted by the Science and Art Department. In November,

FIG. 7. Universal Rolls for Armor Plates (St. Jacques Works).

1878, a scheme was adopted for object teaching, but object lessons had not been as yet recognized in any way by the Education Department. In June, 1881, however, a memorial was presented, asking that object lessons should be fully recognized and considered as an essential part of the instruction in infant-schools, and as a result, the code of 1882 specified that in assessing the merit grant in infants' departments, regard was to be had "to the provision made for * * * simple lessons on objects and on the phenomena of nature and common life." It also recognized as a "class subject" in the upper departments, elementary science, which was defined as "a progressive course of simple lessons * * * adapted to cultivate habits of exact observation, statement and reasoning." Object teaching is now part of the regular course; inspectors have to give special attention to object lessons, and intuitive instruction is encouraged by providing rarer objects, and by offering a museum cabinet to any school in which a good commencement of a collection has been made.

As the Board is obliged to provide elementary instruction for *all* children, it has to furnish special instruction for a considerable number of deaf and dumb, and blind children. The deaf and dumb children are collected and taught at centres, of which there were a year ago thirteen. The number on the roll at these centres was 351, and the average attendance 286. The instruction was upon a combined articulation and finger alphabet system until July, 1877, when the oral system, which is now used, was adopted. Deaf and dumb children cannot be taught with speaking children, and, therefore, are kept in entirely separate classes and are not examined by the inspectors; but blind children usually attend the ordinary day-schools and share, as far as possible, the general instruction, receiving, however, on specified days, special instruction at centres, of which there were last year eighteen, and the total attendance at them was 132. Here the children are taught reading and writing by means of the "Braille" system and by the aid of Moon's type; written arithmetic by means of Taylor's arithmetic boards; and geography with relief maps and globes. Mental arithmetic receives special attention.

Manual Training.—An experiment of instructing boys in the use of tools was commenced in the Beethoven Street School, Queen's Park Estate, in September, 1885, the School-keeper of that school having been a carpenter by trade, and the boys were taught by him, under superintendence of the head master, two afternoons in the week.

The Annual Report of the School Board for 1888 states that an attempt is being made "to develop some regular system of working by which a boy can first draw, and then, from his own drawing, make a series of joints of increasing difficulty." Some articles have been made which are used in the board-schools, but the aim is "to give the boys the best possible course in practice, and to keep the question of utility in the background, only employing it to add a little zest or encouragement when the working of exercises seems likely to pall." This method of procedure is quite the opposite of the course pursued in the French schools, and it is the opinion of the writer that the French system is the best.

The Local Government Board would not approve of payments in connection with this experiment in manual training, and thereby prevented the opening of five additional classes which had been sanctioned by the School Board. Application was then made to the Education Department, requesting that manual training should be placed on the list of specific subjects under the code of the Department, but the reply was received that this could not be done until the question of technical education had been fully considered by Parliament. The School Board is still in hope that alterations in the code may be made that will allow manual training to be made a part of the ordinary school curriculum.

In May, 1887, the London School Board was requested by the City Guilds to appoint a deputation to consult with a number of their members, on a scheme for the equipment and maintenance, for one year, of four schools of elementary technical education, at a cost of about £1,000. The result was the establishment, by the Joint Committee, of six centres at which classes could be conducted, three north and three south of the Thames. The School Board could not legally render pecuniary aid to this object out of the

public funds, but it agreed to grant the necessary premises free of charge, and the expense of maintenance was undertaken by the City Guilds' Institute. The instructors had no specific directions as to the method of instruction, but were allowed to carry out their own ideas, subject to the broad line laid down under the following syllabus:

I—*Woods commonly used:*

(*a*) Conditions of growth.
(*b*) Felling and seasoning of timber.
(*c*) Properties of woods.
(*d*) Heartwood, sapwood, etc.
(*e*) Geographical distribution.

Museum of prepared specimens of woods to be formed in each centre.

II—*Tools:*

(1) Boy's set.
(*a*) Description.
(*b*) Manipulation.
(*c*) Sharpening.
(2) "Centre" set.
(*a b, c*) As above; less of detail.
(3) Nails and screws.
(*a*) Kinds.
(*b*) Uses.
(4) Two-foot rule.
To be specially treated.

III—*Practical work* (*A*):

Measuring and sawing to line.
Squaring piece of wood.
Nailing and screwing.
Simple joints.
(*a*) Exhibition of model of joint.
(*b*) Explanation of drawing of joint.
(*c*) Connection between model and drawing.
(*d*) Preparation of working drawings.

IV—*Practical work* (*B*):

(*a*) Construction of simple joints according to model and drawing.

(*b*) Construction of simple objects founded on simple joints.

V—*Practical work* (*C*):

(*a*) Gluing.

(*b*) Hinging.

(*c*) Knots, tying, etc.

Under the plan adopted, a class is conducted at a particular centre from 9 to 12 in the morning, once per week, and is attended by about thirty boys, drawn from the surrounding schools within a radius of about a mile. In the afternoon of the same day a second class is conducted, attended by another set of scholars; thus allowing for sixty boys to receive instruction at one centre during the day, on the north of the river, and sixty at another centre, south of the river, there being two instructors and two assistant instructors. During the five days of the week, the instructors take the various centres in rotation. Each boy is taken from his ordinary lessons only once per week, and the manual training lesson is made of a more satisfactory length than if the boy attended oftener for a shorter length of lesson each time.

The actual attendance at these schools is about ninety to ninety-six per cent. of the possible attendance. The workshops in each case consist of a single room, and are fitted with work-benches, varying in size according to the number of scholars which the room will accommodate, being generally each about 14 feet long and 2 feet wide. The benches are fitted with vises and other necessary attachments. It is intended to employ about thirty boys at a time, and the approximate arrangement is to have five benches with six vices each. This is different from the French practice, where smaller benches are used, and each boy has his own bench to himself—certainly a much better arrangement.

Each boy is provided with a set of tools, and in addition,

there are certain general tools for common use. Tool baskets, tool cupboards, sawing stools, etc., are also provided.

To assist in giving the pupils an intelligent idea of materials, two museums have been formed, one for the schools on the north side of the Thames, and the other for those on the south, consisting of suitable specimens of wood, properly labelled.

The cost of furnishing each centre is about £38 to £40, and the running expenses, including salaries, amount to about £370 per year, with an addition of £2 per month for timber.

Examinations are held in the autumn, and prizes are offered in competition.

The scheme worked very satisfactorily, and, on the recommendation of the committee, it was continued in 1889, the pecuniary aid being again furnished by the City Guilds. Owing to the success attending the manual training classes for boys as well as the cookery schools for girls, it was deemed advisable by the committee to extend the advantages of instruction in manual training for girls, and to this end several laundry classes were started, as an experiment, under the control of the Joint Committee. Five centres were established: two north and three south of the Thames. Instruction is given at each centre once per week, the hours being from 10 to 12 in the morning and from 2 to 4 in the afternoon, and the work is carried out in accordance with the following programme:

SCHOOL BOARD FOR LONDON.

Laundry Classes.

PROVISIONAL SYLLABUS.

I—*Work to be accomplished:*

(*a*) Washing of flannels, fine things, table linen, body and bed linen and prints.

(*b*) Folding, mangling, starching, ironing and glossing.

II—*Plan of carrying out the work:*

First Lesson.

(*a*) General idea of washing.
(*b*) Order of work to be done.
(*c*) Composition, action and use of soap, water, soda, blue, borax, and of alkalies and acids.
(*d*) Demonstration and practice.
(1) Removing stains.
(2) Disinfecting.

Second Lesson.

Washing flannels and Jaeger garments. Notes and practice.

Third Lesson.

Washing of fine things, viz: Laces, collars, pocket handkerchiefs, cuffs, etc. Notes and practice.

Fourth Lesson.

Washing of table linen, bed and body linen, prints, drying, folding and mangling.

Fifth Lesson.

Recipe for mixing cold starch; cleaning and heating of irons; management of fire; arrangement of iron table; ironing of collars and cuffs. Notes and practice.

Sixth Lesson.

Mixing of boiled starch; ironing the boiled starch things. Notes and practice.

Seventh Lesson.

Children, if possible, to bring small articles of their own to be washed, dried and folded by themselves.

Eighth Lesson.

Finishing of last week's practice by starching and ironing without aid, if possible. Glossing to be taught.

Ninth Lesson.

Written examination and practice lesson.

In the Autumn of 1887, a class was started for instruction in the "Slöjd" system of handicraft, and held on Sat-

urday mornings at the Medburn Street Board School, the course taking a period of three months. The class at first consisted of eighteen boys and two girls, but was afterward reduced to twelve, the number recommended for a class by Herr Saloman of Nääs. Some of the boys were very successful and reached such proficiency that they could go on without supervision, but others progressed very slowly. The girls worked equally well with the boys. The decision of the local Government Board that no expenses could be allowed on account of this instruction, obliged the discontinuance of the class, but it was afterward sanctioned for a further period of three months on a member of the Board agreeing to become responsible for the payment of the teacher's salary for that length of time.

There was a special committee appointed by the School Board of London in 1887 "to consider the present subjects and modes of instruction in the board-schools, and to report whether such changes can be made as shall secure that children leaving school shall be more fitted than they are now to perform the duties and work of life before them." This committee, after a full consideration of the whole subject for twelve months, including the taking of evidence from representatives of various classes of persons able to throw light upon the matter, made a report, in which were the following recommendations:

(1) That the methods of Kindergarten teaching in infants' schools be developed for senior scholars throughout the Standards in schools, so as to supply a graduated course of manual training in connection with science and object lessons, but not so as to include teaching the practice of any trade or industry; and that the method of Kindergarten in the senior schools be tried at first in a few special schools throughout London.

(2) That the teaching of all subjects be accompanied, where possible, by experiments and ocular demonstration, and that the School Management Committee be authorized to supply the necessary apparatus.

(3) That the Board encourage modelling in clay in all

departments of schools, both in connection with drawing as a training of the artistic faculties, and for the illustration of the teaching of geography and other subjects.

(4) That all manual instruction should be given in connection with the scientific principles underlying the work, and with suitable drawing and geometry.

(5) That, as soon as the Board are permitted by law to give special instruction in manual work, the School Management Committee bring up a scheme for giving such instruction.

(6) That classes for instruction in Slöjd be established in three selected schools approved by the School Management Committee.

(7) That the instruction in the classes for manual work and Slöjd be given only by such teachers as have qualified for that purpose.

(8) That as opportunity offers, accommodation shall be provided in connection with each boys', girls', and senior mixed department, in which instruction in manual and other practical work shall be given.

(9) Not important to present inquiry.

(10) That greater attention be paid to the teaching of mechanics as a specific subject, and that models for illustrating the instruction be placed on the requisition list.

(11) That instruction in practical geometry be included in the teaching of drawing, and that mechanical drawing to scale, with actual measurements, be encouraged in all boys' departments.

(12) That instruction in drawing be given in all girls' departments, though it be not necessarily taken as a subject of examination.

(13) That instruction in cookery be given only to girls over eleven years of age without regard to Standard, unless the express permission of the School Management Committee has been previously obtained, and that the necessary additional cookery centres be provided.

(14) That the time now given for dictation be reduced in all Standards, and that in substitution for the part omitted in the lower Standards, the reproduction by children

in their own words of passages read out to them, and in Standard IV and upwards, original composition, be usually taken.

(15) That the teaching of reading should be specially directed to give children an interest in books and to encourage them to read for their own pleasure, and that reading books should be used for imparting a knowledge of geography, history, social economy, and facts of common life to all children, who may not be able to take such subjects for examination.

(16) That, in order to allow time for experimental teaching and manual work, the time now given to spelling, parsing and grammar generally, be reduced.

(17) That the Board authorize the appointment of one or more additional instructors who shall give instruction on the peripatetic plan, in the science subjects authorized by the new code, as the necessity arises.

[*To be continued.*]

PROCEEDINGS

OF THE

CHEMICAL SECTION,

OF THE

FRANKLIN INSTITUTE.

[*Stated Meeting, held at the* INSTITUTE, *Tuesday, June 17, 1890.*]

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, June 17, 1890.

Dr. H. F. Keller, Vice-President, in the Chair.

Members present—Dr. L. B. Hall, Dr. H. W. Jayne, Prof. R. L. Chase, Mr. G. L. Norris, Prof. E. F. Smith, Mr. Reuben Haines, Mr. A. A. Moore, Mr. H. Pemberton, Jr.

A letter from Dr. Wahl was received, announcing that indisposition prevented him from being present to read his paper illustrating the practical working of his process for the electro-deposition of platinum.

Prof. E. F. Smith read a valuable paper on the "Oxidation of Sulphur in Sulphides by Means of the Electric Current." The paper called forth some interesting comments from Drs. Hall and Keller and Mr. H. Pemberton, Jr. It was referred for publication in the JOURNAL OF THE INSTITUTE and in the *Berichte der deutschen chemischen Gesellschaft.*

Adjourned.

WM. C. DAY,
Secretary.

On the ELECTRO-DEPOSITION of PLATINUM.

By Wm. H. Wahl.

[*Read at the Stated Meeting of the Chemical Section, May 20, 1890.*]

The permanence and unalterability of the metal platinum—properties which make it of such inestimable value to the chemist—have likewise suggested its application as a protective covering upon the surfaces of other metals; and, even in the early days of the art of electro-deposition, efforts to obtain a satisfactory coating of this metal were made. The failure with which these early experiments were attended, served rather to stimulate than to deter subsequent investigators, and the problem has received the attention of a number of the most noted experts in the art. The results that have been accomplished cannot be said to have been entirely satisfactory—a statement which, I believe, will be fully sustained by the fact that electro-plating with platinum, on the commercial scale, is practised only to a very limited extent. When the wide field of application for platinum-plating is considered—and I need only name philosophical, engineering, surgical, dental and electrical apparatus and instruments, fire-arms, watch-cases, and jewellery, to say nothing of the host of miscellaneous articles of utility and ornament to which the metal could be advantageously applied—the conclusion is warranted, that the processes thus far proposed for the purpose do not fully meet the requirements of practical service.

Thus far, of all the methods that have been proposed for electro-plating with platinum, three only appear to have sufficient merit to deserve special notice; these are:

(1) Roseleur-Lanaux' method, based on the electrolysis of a solution of the double phosphate of sodium and platinum.

(2) The process of the Bright Platinum Plating Company (of London), a modification of that of Roseleur, involving

the introduction into the bath of certain substances, such as sodium chloride and borax, to ensure a bright deposit of the metal; and

(3) Boettger's method, founded on the electrolysis of a solution of the double chloride of ammonium and platinum in sodium citrate.

Each of these baths will yield satisfactory results for a time; but, as I shall endeavor to show, the peculiar difficulties met with in the practice of platinum-plating render it impossible to maintain the chemical integrity of these electrolytes, and, in conseqence thereof, they soon become inefficient or inoperative by reason of contamination with the secondary products formed therein.

I will endeavor in what follows to give the true explanation of the difficulties above referred to, and to indicate what, from a careful study of the subject, fortified by the results of numerous experiments, I conceive to be the only feasible method of overcoming them.

The first difficulty encountered is that of obtaining a bright, reguline and adherent deposit of the metal, in which form only it will answer the demands of practice. There is no difficulty in effecting the separation of the metal from solutions of almost any of its compounds. Zinc, iron and tin reduce it promptly by simple immersion, and this very facility of reduction is one of the reasons why, even by the method of electrolysis, the desired object is frequently accomplished only in an imperfect manner; for the electroplater is obliged to meet and overcome its obstinate disposition to separate from many of its compounds in the condition of platinum black, lacking coherence and adherence, and therefore entirely unsuited for his purpose.

Another and no less serious difficulty arises from the insolubility of plates or sheets of this metal as anodes, when solutions containing platinum salts are submitted to electrolysis. In electro-plating with copper, silver, gold and nickel but little difficulty is encountered in practice on this account, since anodes of these metals are freely soluble in many solutions capable of depositing them when they are submitted to electrolysis, and the rate at which these anodes

are respectively dissolved, approximates so nearly to that at which the metals are deposited upon the objects at the cathode, that the metallic strength of the electrolyte is maintained substantially constant, and electro-plating solutions of these metals may be operated for a long time without requiring additions of metallic salts. The electro-deposition of the metals whose anodes are thus tractable is carried on industrially with success.

It results from this want of solubility of the anode that the metallic strength of the electrolyte employed is continuously being weakened, while the deposition of the metal is going on, and the conductivity of the bath is being continually modified thereby. The character of the deposited metal also is injuriously influenced by these constant alterations of condition in the bath; and, as the rate of deposition becomes slower and slower by reason of the gradual impoverishment of the metallic strength of the solution, it becomes necessary to restore it by fresh additions of metallic salt. The practice in all the processes of electro-plating with platinum employed up to the present time, save that of Boettger, is to use for this purpose the tetra-chloride of platinum. With this single exception, all the solutions for the electro-deposition of platinum thus far made known, so far as I am aware, are made by treating the chloride with compounds of the alkalies, soda, potassa, or ammonia. Of these, the phosphates and oxalates of soda, or potassa, are in greatest favor, and a number of formulæ for preparing platinum-plating baths with their aid have been described. The resulting substance is commonly a double salt, such, for example, as the double phosphate of sodium and platinum; the double oxalate of potassium and platinum, etc., contaminated, however, in each case by the chloride of the alkali employed, which is formed from the decomposition of the platinic chloride. As often as it is found necessary to strengthen the bath, fresh additions are made of platinic chloride, which, by chemical interaction with the constituents of the bath, aided by the process of electrolysis, yields more alkaline chloride; and it follows that the bath, by reason of becoming surcharged with this foreign substance,

and with other secondary products of electrolytic decomposition, ceases to yield bright, reguline platinum upon the articles to be plated therewith and must be discarded. It then becomes necessary to regain the platinum contained in the discarded bath, by one or another of several processes of reduction known to chemists. The platinum thus regained may be converted into chloride and utilized in the preparation of a fresh bath, with which the same series of operations may be repeated. Boettger purposes to maintain his bath by fresh additions of his original solutions, but it must be apparent that the continued electrolysis of such a solution as he employs must be attended with the constant accumulation therein of alkaline chlorides from the same causes as those specified above. This rapid deterioration of the baths, therefore, involves their frequent renewal at the expense of time and labor, so that, in spite of the fact that there is a wide field for its application, it is principally for this reason that the art of electro-plating with platinum on the commercial scale has thus far been practised only to a very limited extent.

It occurred to me that it might be practicable to overcome the principal difficulty here set forth. Knowing the influence of extent of surface in promoting the solubility of substances, it appeared to me at least probable that if the platinum were exhibited at the anode in the form of platinum-black, or sponge, exposing thus an enormously greater number of points of attack to the electro-negative element or acid radical there set free, the result might be the solution of the platinum, and the problem of maintaining the metallic strength of the electrolyte would thus be solved. The correctness of this conjecture was verified by experiment. For this purpose a plate of porous battery carbon, previously treated with boiling hydrochloric and nitric acids, was saturated repeatedly with a solution of platinic chloride and dried. It was then introduced into a graphite crucible, finely divided carbon was packed about it, and the crucible and contents heated for about half an hour to bright redness. The carbon plate then contained within its pores platinum in a state of eminently fine division. Treatment with water,

and with hydrochloric acid at boiling temperature, failed to leach out any platinum salt, showing that the previous treatment had sufficed to reduce all the platinum salt to the metallic state. The carbon plate was then suspended as the anode in moderately diluted hydrochloric acid, a platinum plate serving as the cathode. The acid bath was gently heated and a current of moderate strength was allowed to flow through it. There was a liberal evolution of hydrogen from the cathode, but little perceptible evolution from the anode. The acid solution gradually became colored from the formation of platinic chloride, and after some time the bright surface of the cathode began to blacken and ultimately became covered with a thick coating of platinum black. It was thus demonstrated that an anode of platinum in the state of fine division is readily soluble in an electrolyte which yields chlorine at the anode when the same is electrolyzed. This observation, so far as I am aware, is new. It proved, however, to have no practical value, since the solution of the anode demanded the presence of a large proportion of free acid in the plating-bath and the use of current of such strength as to produce invariably the deposition on the surfaces to be plated, of black and non-adherent metal. Furthermore, it was found as was to have been anticipated, that the physical condition of the anode exerted no influence whatever in the electrolysis of baths formed of the oxysalts of platinum, from which the best results in electro-plating are obtained—since, in electrolyzing such compounds, the acid radical separated upon the surface of the platinum black failed to exert any perceptible solvent action.

It was therefore necessary to devise some other plan for overcoming the difficulties herein described, and, after making a number of fruitless experiments, I was so fortunate as to find a plan which appears to offer a solution of the troublesome problem of electro-plating with the group of metals, whose anodes are insoluble, in a more satisfactory manner than any other that has hitherto been suggested.

The plan here referred to consists in employing platinum

hydroxide for the purpose of maintaining the metallic strength of the plating-bath. For this purpose, the hydroxide, which is readily soluble in alkalies and in many of the acids, may be introduced into the plating-bath from time to time and dissolved therein by stirring, or it may be permitted to remain in the bath in excess, the undissolved portion remaining at the bottom of the containing vessel, or it may be suspended in a canvas-bag adjacent to or surrounding the anode of carbon, according as the nature of the electrolyte may indicate one or the other method to be the preferable one. As the solutions which yield the best results in plating are those of the oxygen salts, I have found it advantageous also to prepare these directly from the hydroxide. This method, I have found, is capable of yielding a number of electrolytic baths of platinum that will maintain their metallic strength approximately unimpaired during electrolysis, and without the objectionable features of introducing into them substances that will cause them to deteriorate by the accumulation therein of injurious secondary products of decomposition, as is the case where such baths are maintained by additions of platinic chloride or alkaline chloroplatinates, as has hitherto been the invariable practice. Referring now specifically to the properties that render the platinic hydrate useful for the purposes above indicated, the following points appear to be deserving of mention.

It is readily soluble in aqueous solutions of the alkaline hydrates, and in a number of acids, mineral and vegetable. In the treatment of the platinic hydrate with aqueous solutions of the alkaline hydrates, the former plays the part of a weak acid forming compounds known as platinates, which are very soluble, and from which the platinum is not precipitated on the addition of an excess of alkali. A weak aqueous solution of sodic or potassic hydrate (but especially the last named) will dissolve a large quantity of platinic hydrate, at the ordinary temperature, though solution takes place more freely, when heat is applied. These solutions, have the advantageous features of being freely conductive of electricity, and of yielding bright, reguline, and adherent electro-deposits of platinum on metallic surfaces previously

prepared to accept the same. Furthermore, with a current of moderate strength, the platinic hydrate only is affected, as is shown by the pronounced evolution of oxygen at the anode and by the total absence of gas at the cathode. Also, it is manifest from the free solubility of platinic hydrate in alkaline hydrate, even in the cold, that if free platinic hydrate be present in a bath of alkaline platinate, the alkali set free in the process of electrolysis will combine with this platinic hydrate to form fresh platinate. For this purpose, it will be necessary either to have present in the bath at all times a small excess of platinic hydrate which may remain upon the bottom of the containing vessel, without interference with the plating, and which may be replenished from time to time; or, to introduce at the end of the day's work, a quantity of the platinic hydrate sufficient to restore the metallic strength of the bath to normal, assisting the solution of the metallic hydrate by stirring, and if necessary by the application of gentle heat. As I have found that the platinate solutions act best when they contain a considerable excess of free alkaline hydrate, being more conductive of the current and yielding the platinum more freely and in the best condition, the addition of the proper quantity of platinic hydrate at the close of the day's work in the case of a bath of considerable volume, or the addition of small quantities at intervals, in the case of a small bath, will be found to answer the desired purpose of maintaining the metallic strength of the bath approximately normal for an indefinite period. In a bath where considerable free alkali is present, the platinic hydrate added as just indicated, dissolves very freely even in the cold. The important fact is to be noticed, that the alkaline platinate solutions may be maintained and operated for a long time in the manner described, since no deleterious secondary products are formed by electrolysis to vitiate and render them inoperative, as will speedily be the case where the platinic chloride is used for this purpose. The mineral acids (hydrochloric, nitric, sulphuric, and phosphoric acids), dissolved the hydroxide freely, as likewise do certain of the vegetable acids, notably oxalic acid, and form with corresponding

salts of the alkalies, double salts, many of which are soluble in water. Of the salts thus capable of being formed, however, so far as I have been able to determine by experiment, only a limited number appear to be adapted to yield a deposit of bright, reguline and adherent platinum. The halogen compounds may obviously be prepared more conveniently by the direct solution of the metal in *aqua-regia* than by the method I have described, but as I have found the oxygen compounds of platinum to yield much more satisfactory results, I therefore exclude them from consideration.

Of the salts that may be formed from platinic hydrate by solution in acids (and in part by suitable combination with the corresponding alkaline compounds to form double salts), three only may be named as sufficiently useful to yield practically valuable results in plating. These are the phosphates, oxalates and acetates, of which also it is practicable to form double salts with the alkalies, soda, potassa and ammonia, which yield bright, reguline and adherent plating.

Oxalic acid, so far as I have been able to determine, is, of all the oxygen acids, the best solvent of platinic hydrate, dissolving it even in the cold, but with great energy when aided by heat, and forming platinous oxalate, with evolution of carbonic anhydride. From this brownish-black or deep blue solution (according to concentration), brilliant reddish-brown scales of the salt separate abundantly and readily from the hot saturated solution. A saturated aqueous solution of the simple oxalate prepared from the hydrate as above described, will yield bright, reguline, adherent platinum when electrolyzed with a comparatively weak current, with evolution of carbonic anhydride at the anode. With a stronger current hydrogen also appears at the cathode. This bath may be maintained indefinitely at normal metallic strength by observing the precaution to add oxalic acid and platinic hydrate in small quantities from time to time; or by keeping constantly at the bottom of the bath some platinic hydrate, and adding oxalic acid in crystals or powder from time to time as may be required

to keep the bath saturated; or, what is much to be preferred, making a supply of platinous oxalate from platinic hydrate in the manner previously described and keeping an excess of this present in the bath at all times. This bath has the same advantages as are possessed by the above-described alkaline platinate baths, of being capable of indefinite maintenance at normal metallic strength and of introducing no substances that will cause its deterioration by the formation of secondary decomposition products.

Phosphoric acid also is a solvent of platinic hydrate. A dilute aqueous solution of this acid will dissolve a small quantity of the metallic hydrate in the cold, and a much larger quantity when aided by heat. With increasing concentration, the solvent power of this acid for platinic hydrate is correspondingly increased. The resulting solution of phosphate of platinum according to the degree of concentration, will be wine-yellow to cherry-red in color, and with a comparatively weak current, will yield bright, reguline and adherent platinum on metallic surfaces properly prepared to accept the same. The electrolysis of this compound also, does not involve the formation of deleterious secondary products, the result of the operation being the separation of the metal at the cathode and of the acid radical at the anode—and of the elements of water which are evolved as gases respectively from anode and cathode. In the operation of the bath, therefore, it will become more and more acid as the metal is withdrawn by the accumulation therein of the phosphoric acid set free at the anode. The maintenance of the metallic strength of the bath, therefore, may be effected as in the foregoing cases by having present therein at all times a small quantity of platinic hydrate or by the addition at the end of each day's work of the quantity of the metallic hydrate which will be required to restore the amount of metal withdrawn. This bath must be worked very acid, and the solution of the platinic hydrate to maintain the strength of the bath must be facilitated by heating, as the solvent power of phosphoric acid for platinic hydrate is much inferior to that of oxalic acid. The double phosphates of platinum with cer-

tain of the alkalies may be formed, which will be capable of yielding a deposit of bright, reguline and adherent metal, and of being maintained approximately at normal metallic strength in the same manner as I have set forth above. I have obtained the best results with the ammonio-platinic phosphate, prepared by adding to the solution of platinic hydrate in phosphoric acid sufficient aqua ammoniæ to cause the same to give an alkaline reaction, which point will be indicated by the formation of a grayish precipitate that will not disappear on stirring; then restoring the acidity of the solution by adding free phosphoric acid in excess, upon which the precipitate readily dissolves. The resulting solution is yellowish or brownish, and yields superb plating; though, on account of the greater difficulty of maintaining its metallic strength by the solution of the hydroxide, it is not so well adapted as the oxalate for the work of electro-deposition on the large scale. The sodio-platinic phosphate, formed in a manner precisely analogous to the ammonia compound just described, will also yield bright, reguline and adherent plating; but I have observed that the soda salt is less freely soluble than the corresponding ammonia compound, and consequently more difficult than the latter to maintain of normal metallic strength.

Platinic hydrate is only very sparingly soluble in strong acetic acid, and it is impracticable to facilitate the solution by boiling, since by persisting in this for a very short time, the hydrate is decomposed and black platinic oxide is formed, which is quite insoluble in this menstruum. I have found, however, that an alkaline acetate bath may be prepared by the addition to the alkaline platinates above described, of as much acetic acid as may be introduced without causing the formation of a permanent precipitate. But although the appearance and quality of the plating obtained with this bath leave nothing to be desired, the bath does not meet the requirements in respect of indefinite maintenance in normal metallic strength and uniform composition. This difficulty, however, as I have observed, becomes less and less pronounced as the bath is made more strongly alkaline,

when it approximates more and more closely to the alkaline platinates; for it is obvious that in the presence of a large amount of free alkali, this would unite with the acetic acid to form a simple acetate. The resulting solution would no longer contain sodio- (potassio-) platinic acetate, but sodic (potassic) acetate, sodic (potassic) platinate, and free alkali. Nevertheless, the presence of acetic acid in such alkaline bath appears favorably to influence the quality of the plating yielded, giving the deposited metal a whiteness approaching that of silver; and since furthermore, acetic acid yields only the elements of water and volatile compounds, when electrolyzed and therefore does not contaminate the electrolytic bath by forming deleterious secondary products, I find its judicious addition to the above-described alkaline platinate baths to present some advantages.

The foregoing comprise the compounds that I have found to yield the most satisfactory results in platinum plating, and I will not tax your patience at this time by an enumeration of the results, either partially successful, or wholly unsuccessful, that I have obtained with a number of differently constituted compounds of this metal.

I append directions for the preparation of the several electrolytic baths above described, and indicate what I have found to be the most favorable conditions for working them.

In conclusion, I desire to make known the fact, which was brought to my knowledge only within the past week, that my friend, Prof. Wm. L. Dudley, of Vanderbilt University, Nashville, Tenn., has independently worked out the problem of electro-plating with iridium in a manner precisely analogous to that which I have herein described with platinum. Prof. Dudley has made no publication of his research, but in a letter, informs me that he employed, as long ago as 1886, the following procedure, which I quote, "a bath of the metal may be composed of either the chloride ($IrCl_4$), the double chloride of iridium and sodium, or a double sulphate of iridium-ammonium. The latter was preferred. The bath was kept saturated with metal by suspending canvas bags in the solution (either near to or around the anodes) containing the hydroxide of iridium."

DIRECTIONS FOR PREPARING THE ELECTRO-PLATING BATHS.—For the alkaline platinate bath, the following directions may suffice:

Platinic hydrate,	2 oz.
Caustic potassa (or soda),	8 oz.
Distilled water,	1 gallon.

Dissolve one-half of the caustic potassa in a quart of distilled water; add to this the platinic hydrate in small quantity at a time, facilitating solution by stirring with a glass rod. When solution is effected, stir in the other half of alkali dissolved in a quart of water; then dilute with a enough distilled water to form one gallon of solution. To hasten solution, the caustic alkali may be gently heated, but this is not necessary, as the platinic hydrate dissolves very freely. This solution should be worked with a current of about two volts and will yield metal of an almost silvery whiteness upon polished surfaces of copper and brass, and quite freely. There should be slight, if any, perceptible evolution of hydrogen at the cathode, but a liberal evolution of oxygen at the anode. I have observed that the addition of a small proportion of acetic acid to this bath improves its operation where a heavy deposit is desired. The anode may be of platinum or carbon, and owing to the readiness with which the metal is deposited an excess of anode surface is to be avoided. Articles of steel, nickel, tin, zinc, or German-silver, will be coated with black and more or less non-adherent platinum; but by giving objects of these metals a preliminary thin electro-deposit of copper in the hot cyanide bath, they may be electro-platinized in the alkaline platinate bath equally well as copper. The bath may be worked hot or cold, but it is recommended to work it at a temperature not exceeding 100° F. It may be diluted to one-half the strength indicated in the formula and still yield excellent results. The surface of the objects should be highly polished by buffing, or otherwise, prior to their introduction in the bath, if the resulting deposit is designed to be brilliant.

The deposition of platinum takes place promptly. In five minutes, a sufficiently heavy coating will be obtained for most

purposes. The deposited metal is so soft, however, that it requires to be buffed very lightly. A heavier deposit will appear gray in color, but will accept the characteristic lustre of platinum beneath the burnisher.

The oxalate solution is prepared by dissolving one ounce of platinic hydrate in four ounces of oxalic acid and diluting the solution to the volume of one gallon with distilled water. The solution should be kept acidified by the occasional addition of some oxalic acid. The simplest plan of using this bath, and which requires no attention to proportions, is simply to work with a saturated solution of the oxalate, keeping an undissolved excess always present at the bottom of the vessel. An addition of a small quantity of oxalic acid now and again will be found advantageous. The double salts of oxalic acid with platinum and the alkalies may be formed by saturating the bin-oxalate of the desired alkali, with platinic hydrate and maintaining the bath in normal metallic strength by the presence of an undissolved residuum of platinous oxalate.

The double oxalates are not so soluble in water as the simple salt. The oxalate baths, both of single and double salts, may be worked cold or hot (though not to exceed 150° F.), with a current of comparatively low pressure. The metal will deposit bright, reguline and adherent on copper and brass. Other metallic objects must receive a preliminary coppering as above. The deposited metal is dense, with a steely appearance, and can be obtained of any desired thickness.

The deposit obtained in the oxalate baths is sensibly harder than that from the alkaline platinate bath, and will bear buffing tolerably well.

The phosphate bath may be prepared by the following formula:

Phosphoric acid, syrupy (sp. gr. 1·7),	8 oz.
Platinic hydrate,	1–1½ oz.
Distilled water,	1 gallon.

The acid should be moderately diluted with distilled water, and the solution of the hydrate effected at the boiling temperature. Water should be added cautiously from

time to time to supply that lost by evaporation. When solution has taken place, the same should be diluted with sufficient water to make the volume one gallon. The solution may be worked cold or warm to 100° F., and with a current much stronger than that required for the platinates and oxalates. The ammonio- (and sodio)- platinic phosphates may be formed from the simple phosphate by carefully neutralizing the solution of the phosphate with ammonia (or soda); then adding an excess of phosphoric acid, or enough to dissolve the precipitate formed and an additional quantity to ensure a moderate amount of free phosphoric acid in the bath. The phosphate baths will be maintained of normal strength by additions of platinic hydrate, the solutions of which will have to be assisted by heating the bath, preferably at the close of each day's work. The metal yielded by the electrolysis of these phosphate solutions is brilliant and adherent. It has the same steely appearance as that exhibited by the oxalate solutions, but to a less pronounced degree. The physical properties of the deposited metal are in other respects like those described in connection with that obtained from the oxalate baths.

BOOK NOTICES.

THE CHRONICLE FIRE TABLES FOR 1890.—A record of fire losses in the United States by risks, States and causes during 1889, etc., and much other interesting and valuable information for fire underwriters. The Chronicle Company, Limited, New York. Royal 8vo, 300 pages. Price, $5.

This elaborate work, which is well denominated "an invaluable compilation of fire statistics," appears as the sixth volume of the enlarged series, showing aggregate property loss, during the year, of $123,046,833, of which $73,679,465 were the insurance losses. Fire underwriters, especially, but also many others, owe a debt of gratitude to the publishers for the carefully prepared and digested data which crowd 225 main pages and seventy-five pages of an appendix, as we shall prove by some examples. Besides the usual principal chart, giving number of fires among industrial works, warehouses, dwellings, theatres, public buildings, school-houses, railroad buildings, etc., burned during 1889, with property loss and insurance loss on the same and causes of fires as nearly as could be ascertained, pages 13 to 31 inclusive,

there are similar tabulations of fires, losses and causes *by States and Territories*, pages 32 to 139, and similar data *by causes*, pages 140 to 200.

The diagrams in this volume are especially valuable. In front, a colored one shows by red and yellow squares the *increase* of property loss, by fires through electric wires and lights, from $460,259 in 1886 to $5,533,820 in 1889! A series of diagrams covering pages 226 to 238, inclusive, shows graphically the proportions between fires of interior and exterior origin in all the numerous classifications. This is the great "exposure" risk, which plays such an important part in fire losses, and which must be studied, and as far as possible avoided (or else duly charged additional premium), by fire underwriters.

Other diagrams (3) show the movement of fire loss in the United States for fifteen years, the monthly curves of incendiary fires for seven years and the annual curves, since 1884, of fires and failures in the United States. The last is particularly suggestive. There are six other diagrams, showing, for the years 1884–1889, the geographical distribution, by States and Territories, of reported incendiarism. The changes indicated are well worthy of study, *e.g.*: In 1884, nine States had over 50 per cent. of their fires reported as incendiary, while in 1889 only three States showed so large a proportion. In 1884, fifteen States had less than twenty per cent. reported incendiarism among fires, but in 1889 the number having this lowest percentage of incendiarism had risen to twenty-two: gratifying progress towards security, exhibited in dual form.

In the appendix are summaries of fires, losses and causes, by certain classes of risks, pages 239 to 297. We could give further illustrations of the excellent and concise mode in which the vast amount of fire data is arranged; but we have said enough, we think, to induce all connected with fire underwriting and the study of law and social economy, to purchase these tables, obtain the previous volumes, if they have them not, and register as subscribers for future issues. N.

BOOKS PURCHASED FOR THE LIBRARY. MAY–JUNE, 1890.

Bale, M. P. A Hand-Book for Steam Users.
Biddle, T. E. A Treatise on Model Yachts.
Bucknill, J. T. Submarine Mines.
Dana, J. D. Characteristics of Volcanoes.
Corals and Coral Islands.
Davies, D. C. A Treatise on Earthy and other Minerals.
Davies, G. C. Practical Boat Sailing.
Dunman, T. A Short Text-Book of Electricity and Magnetism.
Earl, A. G. Elements of Laboratory Work.
Encyclopædia of Monograms.
Grosvenor, J. duV. Model Yachts and Boats.

Hepworth, T. C. Photography for Amateurs.
Hough. The American Woods.
Kemp, D. A Manual of Yacht and Boat Sailing.
Liesegang, P. A Manual of the Carbon Process.
Neison, A. Practical Boat Sailing.
Pringle, A. Practical Photo-micrography.
Richards, J. W. Aluminium. (Second Edition.)
Scott, R. P. Cycling Art.
Speed, H. F. Cruises in Small Yachts.
Vaux, C. B. Canoe Handling.
Watt, A. Art of Leather Manufacture.
Art of Paper-making.
Art of Soap-making.
Wegmann, E. Masonry Dams.
Weisbach, P. J. Manual of Mechanics.
Wilkinson, W. T. Photo-engraving, Photo-etching, etc.
Winchell, A. Geological Excursions.
World-life.

JUNE.

Bresson, M. L'Acier.
Church, A. H. The Chemistry of Paints and Painting.
Clarke, T. C., and others. The American Railway.
Congrès Internationale de Géologie. Premiere et deuxième Session.
Fleming, A. J. The Alternate Current Transformer.
Friedlaender, Dr. P. Fortschritte der Theerfarbenfabrikation.
Ganswindt, Dr. A. Handbuch der Färberei.
Gerhard, W. P. The Disposal of Household Wastes.
Glazebrook, R. T. and N. W. Shaw. Practical Physics.
Glazebrook, R. T. Physical Optics.
Gottgetreu, Rudolph. Physische und chemische Beschaffenheit der Baumaterialien.
Groth, P. Tabellarische Uebersicht der Mineralien.
Judd, J. W. Volcanoes.
Julius, Dr. Paul. Die künstlichen organischen Farbstoffe.
Kerl Bruno. Grundriss der Metallhüttenkunde.
Kohler, G. Lehrbuch der Bergbaukunde.
Langley, S. P. The New Astronomy.
Liebig's Annalen der Chemie, 153 Vols., 1832 to 1890.
Milne, J. Earthquakes.
Monie, H. The Cotton Fibre.
Rosenbusch, H. Mikroskopische Physiographie der Mineralien und Gesteine.
Rosenkranz, P. H. Der Indicator und seine Anwendung.
Sawyer, J. R. The A B C Guide to the making of Autotype Prints.
Serlo, Albert. Leitfaden zur Bergbaukunde.
Tiemann, F. und A. Gärtner. Die chemische und mikroskopisch-bakteriologische Untersuchung des Wassers.

Wagner's Jahresbericht über die Leistungen der chemischen Technologie, 1889.
Ware, W. R. Modern Perspective.
Weber, Martin. Das Schleifen, Polieren und Färben des Marmors.

GIFTS TO THE LIBRARY OF THE FRANKLIN INSTITUTE.

American Atlas. Historical, Chronological and Geographical. From Wm. C. Desmond.
American Machinist. Two copies. From Spencer Fullerton.
Baltimore. Sixty-first Annual Report of the Board of Commissioners of Public Schools. From the Board.
Beale, Lionel S. Disease Germs. From Dr. Isaac Norris, Jr.
Binghamton, N. Y., Water Commissioners' Annual Report. 1889. From the Commissioners.
Birkinbine, H. P. M. Pumping-Engines for the Water Supply. From Spencer Fullerton.
Boston Public Library. Bulletin No. 80. From the Library.
Bourne, John. Catechism of the Steam Engine. From Spencer Fullerton.
Brooklyn Library. Thirty-second Annual Report. From the Directors.
Bureau of Water, Philadelphia, Annual Report. 1888. From Spencer Fullerton.
Canadian Society of Civil Engineers. Charter, By-Laws, etc. From the Society.
Chronicle Fire Tables. 1890. From the Chronicle Company, Ltd.
Civil Service. Regulations and Improvements. From Spencer Fullerton.
Commercial Exchange. Philadelphia. Thirty-sixth Annual Report. From the Secretary.
Connecticut State Board of Health. Twelfth Annual Report. From the Board.
Dana, J. D. Manual of Mineralogy. From Spencer Fullerton.
Deutsch-Amerikanischen Techniker-Verbandes. Mittheilungen. May, 1890. From the Techniker Publishing Company.
Engineers' Society of Western Pennsylvania. Proceedings of April Meeting. From the Society.
Fisher's Mathematics Simplified. From Richard W. Gilpin.
Foulke, William Parker. Memoir. From Richard W. Gilpin.
Fox, L. Webster. A History of Spectacles. From the Author.
Geological Survey of India. Palæontologia Indica. Series 13, Vol. 4, Part 1. From the Survey.
Geological Survey of New Jersey. Annual Report of the State Geologist for 1889. From the Survey Office.

Germanischer Lloyd. Zweiter Nachtrag Internationales Register. From L. Westergaard & Co.

Gilpin. Central Gold Region. From Richard W. Gilpin.

Grand Trunk Railway Company, of Canada. Report of the Directors. December 31, 1889. From the Company.

Guatemala. Informe de la Direccion General de Estadistica. 1889. From the Director General.

Hart, W. F. A Tabular Statement of the Principal Provisions in the Patent Laws. From the Author.

Harvard College Observatory Annals. Vol. 18, No. 10. Henry Draper Memorial. Fourth Report. From the Director of the Observatory.

Historical Sketch of the Invention of Vertical Tubular Boilers. From Spencer Fullerton.

Houpt, J. Improvements in Steam Engines. From Spencer Fullerton.

Insurance Company of North America. A History. From Spencer Fullerton.

Interstate Fair Association, New Jersey. List of Prizes. From the Association.

Johns Hopkins University Register. 1889–90. From the University.

Kennedy, J. H. The Three Witnesses of the Book of Mormon. From Secretary, Oneida Historical Society.

King, W. H. Practical Notes on the Steam Engine. From Spencer Fullerton.

Lombard Investment Company. Annual Report. From Spencer Fullerton.

Louisiana Board of Health. Biennial Report. 1888–89. From the Board.

Massachusetts State Agricultural Experiment Station. Analyses of Commercial Fertilizers. May and June, 1890. From the Station.

Franklin Institute.

[*Proceedings of the Stated Meeting, held Wednesday, June 18, 1890.*]

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, June 18, 1890.

CHAS. BULLOCK, Vice-President, in the Chair.

Present, forty-one members and eight visitors.

Additions to membership since previous meeting, thirteen.

Mr. S. LLOYD WIEGAND (in place of Mr. FRANCIS LECLERE, absent on account of illness) gave a description of an improved spindle support devised by Messrs. Bates, Shaw & Von Culin. Mr. WIEGAND illustrated the subject

with the aid of a very complete exhibit of various forms of these devices, ancient and modern, and with several views of spinning frames.

Mr. W. N. JENNINGS exhibited on the screen and described a series of remarkable photographs of lightning flashes, which he had succeeded in obtaining in the neighborhood of Germantown during the violent thunder-storm of June 11th. One of these exhibited the appearance of a number of *black* branches radiating from the bright main stem of the flash. This singular phenomenon evoked considerable speculation as to its cause, and opinions thereon were ventured by Messrs. WIEGAND, SARTAIN, IVES and JENNINGS.

The Secretary presented an elaborate account of the present state of the art of electric welding, as represented by the Thomson Electric Welding Company's operations. He referred, among other things, to the fact that the system had already passed the experimental stage, and gave an account of the various uses to which it had already been successfully applied. He referred to, and quoted from, special reports that had been made on the system by Mr. Alex. B. W. Kennedy, F.R.S.; Prof. Silvanus P. Thompson, F.R.A.S., and the United States Naval Board, appointed by the Secretary of the Navy. The Secretary's remarks were illustrated with the aid of lantern pictures, showing several forms of the welders used in service.

Mr. F. L. GARRISON, seconded by Mr. WIEGAND, offered the following:

WHEREAS, It is the purpose of the British Iron and Steel Institute and the German Society of Iron Masters, to visit this city in a body during October next, with the object of viewing our industries and institutions; and,

WHEREAS, It is the policy and pleasure of this INSTITUTE to extend its privileges to the representatives of such distinguished foreign institutions;

Therefore, RESOLVED, That the FRANKLIN INSTITUTE hereby extends the use of its Hall and the privileges of its library to the visitors during their stay in the city.

Adopted unanimously.

Mr. W. E. LOCKWOOD laid before the meeting copies of pending bills before Congress, appropriating $25,000 for the purpose of determining the amount of the so-called hammer-blow of a locomotive driving-wheels; also, for appropriating $500,000 for the erection of an additional fire-proof building for the National Museum.

Dr. ISAAC NORRIS, on behalf of Mr. Gutekunst, presented a neatly-framed photograph of the late GEORGE S. PEPPER.

Adjourned.

WM. H. WAHL, *Secretary.*